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TITLE: Program Description of the Modified Thermal Analyzer Digital Computer Program

ABSTRACT

The Thermal Analyzer Program (TAP has undergone a series of modifications for operation on the IBM 360/65. These modifications have increased its flexibility to handle a variety of heat transfer problems, reduced the cost of running the program, reconstructed the program layout to facilitate further changes, and streamlined the data input to the program. The programming performed to achieve these results is described. Subroutine level flow charts are included along with a program listing. This document acts as a supplement to TM 4942:69:602 and describes the program from a programmers point of view.

KEY WORDS: program description, computer program, thermal analysis, transient, steady state, heat transfer

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PROGRAM DESCRIPTION OF THE MODIFIED THERMAL ANALYZER DIGITAL COMPUTER PROGRAM

1.0 INTRODUCTION

The Thermal Analyzer Program (TAP) was originally conceived and written at Lockheed, Sunnyvale. Variations of the original program have been made and have come into fairly wide use in the aerospace industry. The current modifications were made with several thoughts in mind: (1) expand the flexibility of the program so that it is more capable of analyzing complete systems; (2) provide a nuclear heating capability compatible with SNAP-8 needs: (3) reconstruct the program in a modular form to facilitate further modifications should they be desired; (4) minimize the amount of core storage used since the program is being run on a time shared machine and computer charges depend on the amount of core used; (5) examine and modify the iteration scheme to increase running speed of the program; (6) modify the input to make the program easier to use and to provide the user with additional flexibility so that he, by using his own ingenuity, could achieve the same results with reduced computer costs or could expand the amount of information he could extract from any computer run; (7) modify the input routines to perform more checking of data to prevent costly, erroneous runs. In each case the intended alterations met with at least some measure of success. In some cases the achieved results exceeded original expectations by a significant amount. It should be pointed out that much of the success of the current work was possible because of a good original concept and organization of the basic solution technique.

The current version of the program has been described by D. E. Knittle (Reference 1). It is the intent of this report to supplement that description by providing information of interest to the programmer. To do this, the specific changes made to the original program are described in some detail. The main computer program and each of its subroutines is described in sufficient detail to permit the reader to follow the path of the program and understand both the reason for the existence of section of programming and its relationship to other sections of the program. A detailed description of the input is also given here, despite the fact that this is well covered in Reference 1. When that document was being written several final changes were in progress. During the

programming effort, it was found that some of the intended alterations were inadvisable, at least at this time. Since the input is not precisely the same as previously described, it was felt advisable to rewrite this entire section rather than just giving the exceptions to the existing documentation. This is done in the description of subroutine FIN.

2.0 THE PROGRAM AND ITS MODIFICATIONS

2.1 AN OVERVIEW OF TAP CONSTRUCTION

The structure of TAP is of the form of a main program which performs the primary calculations and also acts as a calling program to permit the activation of a group of subroutines to perform the secondary calculations. Since the program is intended to solve a diverse range of heat transfer problems it is necessary to provide the capability to perform a variety of calculations without requiring that each of them be performed on each pass through the program. This can be achieved by providing sufficient flexibility in the input data to permit the user to control the calculations to be performed. In the TAP program the data consists of required data, in the form of thermal conductance, capacitance and initial temperatures, and of optional data, in the form of functions and tables which are called by the main program only when required to solve the problem at hand. The first task in the program is to read in the required data and then read in the optional data and set appropriate flags for each option chosen.

TAP uses a finite element approach to solve transient heat transfer problems. A full explanation of its capabilities and the equations used to perform the calculations are described in Sections 3 and 4 of Reference 1. A full description of each routine used in the program and its function are given later in this report. The program first calculates the time step to be used in the next iteration. This is calculated to find the maximum time step possible without causing an instability in the numerical solution of the transient partial differential heat transfer equations. If a maximum time step is chosen by the user then this becomes the time step instead of the one calculated, provided a conflict with the stability criterion does not exist.

If fluid flow calculations have been specified in the data these calculations are performed. A check is then made to determine whether results are

to be printed after the current time step; if it is, a flag is set. Next, the nuclear heating calculations are called for if specified in the data. The calculation of nodal temperatures (primary calculations in the program) occur next. Options are then tested for a specialized fluid flow routine, for a steady-state check, and for a fluid flow temperature averaging scheme. If the print flag is set a print is obtained; if not, options are tested for use of the tables, radiation heat transfer calculations, aerodynamic heating calculations, cathode follower calculations, and latent heat calculations. The end of the transient is then tested for and if not found the calculations continue.

All of the calculations which can be called for data options are contained within separate subroutines where there are a sufficient number of calculations to justify a subroutine. Most of these are specified in the FIN program by an explicit function number. Function data is passed between subroutines through commons (FUN1, FUN2, etc.). Other information is passed as arguments to the subroutines.

Only one fundamental change in the program has been made and should be noted: wherever possible, thermal resistances which appeared in the original have been replaced by conductances for the purpose of internal calculations. Resistances are denoted by R and conductances by COND in the program nomenclature. Parallel resistance paths are added as a sum of reciprocals. These same paths require only addition when handled as conductances. This change significantly reduces the number of divisions required to perform the arithmetic and consequently speeds the run time of the program.

2.2 PROGRAM FLEXIBILITY AND NUCLEAR HEATING

Before alterations were made, the TAP program was most applicable for simple conductive networks. Through the intelligent use of this network it was possible to also perform some limited fluid flow calculations. Within these limitations the program was quite flexible permitting various types of heat input, radiative and limited convective heat transfer, and the ability to vary resistors, capacitors, temperatures, or heat inputs as a function of time, or as functions of each other by using the tables. The program also contained a subroutine to calculate heat input to a node in an arbitrary manner by the user.

The arbitrary heat input subroutine was removed since it was determined to be of limited utility. In its place, a nuclear heating program was constructed which was consistent with the design of the SNAP-8 reactor. The equations used in this subroutine are given as 2.7.8 to 2.7.11. Equation 2.7.8 is the neutron flux equation for a single group of delayed neutrons and is derived making the assumptions that the reactor has been at steady state for a sufficient period of time for all the precursor groups to be at equilibrium and that the reactivity is about 2.5×10^{-3} or less, i.e. $(\beta - \rho + \ell\lambda)^2 \gg | 2\ell\lambda\rho |$.

Equation 2.7.9 is a simplified equation for decay heat. Under normal operating conditions the beta and gamma heating is approximately 6% of the total heat generated. This rapidly drops to about 3% if the reactor is shut down. These facts determine the following method of calculating reactor heating. If the power is at or near the base power, the beta and gamma heating closely follows the neutron heating and Equation 2.7.8 is used. If the reactor is shut down Equation 2.7.9 is used. Between these two extremes a combination of the two equations is used. Let us say that the power is dropped to 50% of the base; the beta-gamma heating should drop off rapidly and the assumption made that all the heating is neutron heating is still a valid one. Now consider the case where the neutron power drops to less than 50% of base power. It is unlikely that this would happen slowly since the reactor is designed to operate at a constant base power level. If it should, then the beta-gamma heating would decay with the power level. Should the power drop rapidly, then the beta-gamma heating becomes significant when the neutron power approaches the beta-gamma heating in level. When neutron power is less than .06 of the base power than the beta-gamma heating is added to 0.94 of the neutron power (that portion actually supplied by neutrons and prompt gammas at full power; the remaining .06 is always provided by the decay betas and gammas). This determines the use of Equation 2.7.10.

Additional flexibility has been given to the program with the implementation of fluid flow capability. Three functions control the use of this capability; Functions 10, 11, and 12. Function 10 provides the basic capability. Heat is transferred by fluid flow from node to node. This capability can be invoked simply by specifying the nodes between which the fluid is flowing, by indexing this information to the table specifying the wc_p as a function of time,

and by specifying the thermal capacitance of the node. Function 11 is used to combine the flow from two or more nodes into a single node and average the temperature. This would be used at the junction point of two or more pipes. Function 12 serves the same purpose as Function 10 except that the fluid is moved through a series of nodes in each iteration. The intent of Function 12 is to replace Function 10 when the use of Function 10 would result in the time steps being significantly reduced in size (which causes a proportionate increase in the computer run time).

One other capability exists in the fluid flow functions. It is possible to leave a fluid node empty until some specified time during the calculations, after which the transfer of heat by fluid flow through the node indicated takes place. This option is also specified in Function 10.

2.3 MODULARIZING THE PROGRAM

The intent of organizing the program in modular form is to separate various sections of programming along functional lines. This facilitates future modification since sections of programming can be removed and replaced intact. It also makes available one common functional base which may be addressed from different sections of the program. This minimizes the need for similar sections of coding to appear at several different locations in the program.

The program as conceived was constructed in good modular forms. It remained to follow the same practices in placing the new coding into the program. The original arbitrary heating subroutine was replaced with the nuclear heating subroutine. Both Function 5, which describes the nuclear heating data, and Function 13, which describes the feedback coefficients and the dead-band temperature data, are used in the nuclear heating subroutine, HEATIN. Functions 10 and 12 are used in subroutine FLOW. Although the calculations called out by these two functions are somewhat different, their basic purpose is the same and they were, therefore, placed together. Subroutine TAVG contains the averaging scheme to mix two or more nodes into a common node and average the temperature. Function 11 calls out this subroutine. Finally a subroutine to test for equilibrium of the entire system of nodes during a transient is separated as subroutine STEADY. In each case, these subroutines could be modified or replaced with a minimal effect on other portions of the program.

A more detailed description of each subroutine, including its ties to other parts of the program, is given later in this report.

One change which was made from the original program was to place the function information into a series of common blocks called FUN1, FUN2, etc. This significantly reduced the number of arguments being passed between certain subroutines and, at the same time, placed all the function information into readily definable blocks. Since almost all the function information is used in modular form, the placement of the function information into discrete modules was also considered advisable.

2.4 CHANGES IN CORE STORAGE

The modifications to the TAP program were undertaken with the intent that the program would be run on an IBM 360 machine. The 360 series provide for a multi-programming environment and computer charges are based on the percentage of core used as well as the actual run time. Because it was possible to have temperatures of 1000° and more, and because of the possibility of small time steps with slowly changing temperatures, it is possible to lose significant accuracy during a transient by using single precision (about 6-1/2 decimal digits of accuracy). Consequently, all quantities used directly in the temperature calculations were typed REAL*8. All other floating point variables were left in single precision. This change increased the core storage. Another increase occurred when it was found advisable to increase the number of conductors (resistors) in the program from 700 to 999. The number of conductors is always larger than the number of nodes (unless the network is a closed circle). In two dimensions the ratio of conductors to nodes is usually in the range 1.5 to 2.0. In three dimensions this ratio is usually 2.0 to 4.0.

Minimization of core storage is partially achieved by not typing all real variables REAL*8. It is further achieved by condensing the integer variables by typing them INTEGER*2. This permits the use of integer numbers with values up to 65,535, which is well beyond any values which would be used in the program. The variables chosen to be typed in this manner are those that are dimensioned. It is here that the greatest savings are to be made. The other integer variables could also be typed INTEGER*2, but in this case care would also have to be taken that they appeared at the end of COMMON lists to avoid

the problem of word boundary misalignment in core. Still another method of core reduction was to critically evaluate all dimensions to eliminate over-specification and to evaluate all coding to eliminate those sections which were no longer necessary for the program to achieve its objectives (one such section was tied to a variable dimensional 5000 which was no longer necessary).

A final method of core reduction was to overlay the program. Only one overlay can be intelligently done and that is to place the input routines, which are used only once, in a separate segment. This segment is composed of subroutines FIN and TABIN, which are input routines as well as READ and READ2, which are called only from the input routines.

The result of all these changes was to reduce the size of the program from just under 200K bytes to less than 150K bytes. It should be mentioned here that two other core reduction mechanisms are readily available. One simple one is to reduce the number of nodes from 700 to 600. It is highly unlikely that more than 600 nodes would be used even if all 999 conductors are used. The variables T, C, Q, RI, TR, IRCVAR and RIFIX could all be reduced in size from 700 to 600. This could also be done with some of the print specifications. Since most of these variables are typed REAL*8 the savings would be significant (more than 5K bytes). The change is not being made at this time because not enough physical cases have been run to show conclusively that this change is advisable. A second change would be slightly more difficult to make. The tables are currently dimensional 104 x 30 (12,480) bytes. All 30 tables are almost never used. Even if they should be used, all 104 positions in all the 30 tables will certainly not be used. It should be possible to halve the size of this array, singly dimension it, and set up a table of pointers to point to the location of the first element of each of the 30 tables.

2.5 MODIFICATION OF THE INPUT AND OUTPUT

Input to the TAP program is through three subroutines, TRCIN, which reads in the conductor, temperature and capacitor data, FIN, which reads in the function data, and TABIN, which reads in the tables. A small utility subroutine with two entry points (READ and READ2) is used by these input routines. These read data in either of two standard input formats.

The first input change was to the first card read in by the program, the title card. Columns 1-5 of every run must read "TITLE." The actual run title begins in Column 7. An option was included to punch the temperature-capacitance cards at the completion of the transient by placing a "1" in Column 6 of the title card. It is standard practice to make a steady-state run before performing a transient analysis. This is because most models which must be solved by computer analysis are sufficiently complicated that the initial temperature distribution is not known. The steady-state run determines these temperatures and punches these out so that there is no need to keypunch this part of the data before running the transients.

Subroutine TRCIN originally read in first the resistor data, the temperature data and the capacitor data, in that order, with a -1 card at the end of each section used as a flag to proceed to the next section. The first change was to combine the temperature and capacitance cards to put the information on one card. Since both of these quantities are specified according to node number, then the card containing the node number can be used to specify both quantities.

The next change was to permit an easier method of specifying sequential conductor or node numbers if the value of the conductance or of the temperature and capacitance is identical. The method chosen to do this was to flag certain of the input fields by negative numbers. Thus, in specifying the input for temperature and capacitance, if a sequentially numbered group of nodes have the same temperature and capacitance, the placement of a -1 in Columns 9 and 10 of the first card of the sequence will result in the internal numbering of all nodes up to and including the last of the sequence. This means that only two cards, the first and last of the sequence, must be specified to define a sequential series of nodes if the first card is flagged with a -1.

The same type of sequential numbering scheme has been programmed for the conductor data. In this case not only must the conductors be sequentially numbered, but the nodes to which they are connected must also be sequential. Prior knowledge that this capability exists makes it easy to take advantage of it when assembling the nodal network. Additional time saving devices are available in the conductor block by proper placement of negative signs. The

sequential numbering of conductors and nodes in this block occurs if negative signs are placed in front of both nodes of the first card in the sequence. If only one of the nodes is made negative that series of nodes and the conductors are sequenced. The other node number is kept constant during the sequencing. This model is representative of several nodes connected to a large heat sink. A detailed description of the input is given in Section 3.2 of this report.

Subroutine TRCIN has also been modified to perform some checking of the input data. If the maximum conductor number exceeds 999 or if the maximum node number exceeds 700 the run is terminated with an appropriate error message. A check is made to assure that no conductor is attached to a non-existent node. If that condition exists a flag is set and the run terminated at the completion of the input checking. Next each node is checked to see that it is connected to a conductor; if not, another error message is printed and a flag set. If a negative capacitance exists for a non-connected node, then it is possible for the node to remain at a constant temperature throughout the problem. Even though this condition provides no useful information, the condition is permitted.

The next check of the input data is to flag the variable conductors. Those that are constant require no further calculations during the transient. Flagging the variable conductors saves computer time by minimizing the calculations required during the transient.

Input to subroutine FIN, to read in the function data, has also been modified to reduce the number of cards necessary to specify the function information desired as well as to perform some input checking.

Functions 2, 8, 10 and 12 have been programmed so that a negative number in Columns 11-15 will act as a flag for sequential numbering. In each case the flag card acts as the initial card in the sequence while the card immediately following it acts as the last in the sequence. A more thorough description of this capability is given in Section 3.3 of this report.

Functions 1-6, 8, and 10-12 are each checked for the amount of input given to their respective functions. If the input exceeds the amount dimensioned in the subroutine an error message is printed and the run aborted. An error of this type could do serious damage to the calculation procedure. In each function where a conductor or node number is referenced, a check is made to be

certain that it exists. If not, an error message is printed, a flag is set, and the run is aborted after the remainder of the data has been checked.

Function 9 input has been modified to provide additional flexibility for the user. Problem constants 1 and 2 in Function 9 previously permitted a single specification for the time interval (if the user chose to over-ride the program calculations) and for the print interval. It is now possible to specify up to 5 intervals during different periods of the transient.

In specifying the print interval it is sometimes desirable to examine output at frequent intervals during a particular stage of the transient. It is now possible to do this and then change to a longer interval to avoid the excessive printout that would result if the shorter interval were continued throughout the transient. The time interval is often specified when the user wishes to examine the changes in temperature resulting from some rapid change specified in one of the tables (usually heat input). He shortens the time interval and the print interval to examine the change in detail. Later in the transient he increases both, permitting the program to calculate its own time interval and shorten the run time of the program.

Other checks are also made in subroutine FIN. Function 8 must be specified or no printed output will result. If Function 8 is omitted, the run is aborted. Checks are also made to be certain that the print interval has been specified (constant 1 of Function 9) and that the problem completion time has been specified (constant 4 of Function 9).

Another change to the input has been the inclusion of a second standard card reading routine which has been included as entry READ2 in subroutine READ. This additional capability consists of the ability to read in two fields of floating point data instead of only one as was previously the case. This serves the purpose of reducing the number of data cards necessary to specify the problem.

The output format for the program has been modified to provide easier user access to the data. Before modification the method of data printout was to first print a format of the output with seven pieces of data per line of line, e.g.:

T(26) T(27) T(106) T(154) Q(27) C(106) T(154)

Thereafter, at each print step only the numbers were printed. It was necessary to remember which number referred to which quantity in the print format, or to continually refer back to the format. If a large number of quantities was being printed this procedure became quite cumbersome.

The current print scheme is to print only five pieces of data per line, with the identification of each quantity printed whenever the number is printed. The FORTRAN output format has been retained as E15.5 for each number printed. In addition, if the nuclear heating capability is used, the δK of the reactor is also printed at each interval. A sample of the output can be found as Figure 10.7 of Reference 1.

2.6 MODIFYING TAP DIMENSIONS

The TAP program as described in this report will handle physical problems which can be modeled with up to 700 nodes and 999 conductors. This capability fits in approximately 150K bytes of an IBM 360 computer. A program of this size is sufficient to give an accurate model of most heat transfer systems that will be encountered. Should additional capacity be desired, the modifications to the program are fairly easy to accomplish. Also, if a smaller version of the program were desired so that it could be run on a small computer, it is possible to reduce the dimensions and also to strip some sections from the program which are seldom used.

To expand the program, most of the changes are in the dimensions. In the main program the dimensions of quantities T, COND, TR, RI, RC, I2V, I3V, C, Q, PRUNT and PRINT would have to be changed. Since PRINT is equivalenced, its boundaries would also require change. In COMMON VARY, IRVAR would be changed as would the dimensioned variables in COMMON FUN8. All variables dimensioned 700 would change to the new node maximum while those dimensioned 999 would change to the new conductor maximum. The DO loops ending at Statements 7 and 8 would require similar changes. Immediately following Statement No. 291 various quantities are referenced for arbitrary interpolations. Where 999 is used as a multiplier it would be replaced by the maximum conductor number; where 299 is used, it would be replaced by the difference of the maximum conductor and node numbers. These same changes would be made in the print section immediately following Statement No. 400. In the other subroutines changes in dimensions would have to be made as follows:

SUBROUTINE	QUANTITIES
TRCIN	IRVAR, I2V, I3V, COND, T, C, RI, TR
FIN	T, I2V,/ FUN8/
TABIN	IRVAR
FLOW	T, C, Q, TR, RI
HEATIN	T, Q
TAVG	T, C, RI
STEADY	T, TSAVE

Also in subroutine TRCIN the DO loop ending at Statement 1 must be changed to fit the dimensions of I2V. Statements 50 and 80 must have their dimensions changed to reflect the nodal and conductor changes.

To obtain a smaller program, say one with 100 nodes and 150 conductors, all the changes noted to increase the program size would be made. In addition, it is recommended that subroutines HEATIN, TAVG, LAT, QECK, and QRW be removed as well as entry FSTFLO in subroutine FLOW. This would also permit elimination of Functions 3, 5, 6, 11, 12 and 13. Functions 1 and 4 could also be removed. The number of tables could be reduced to 15 and pointers used to conserve space. Function 2 would be dimensioned 50; Function 7, 50; Function 8, 100; Function 9, unchanged; Function 10, 50; and Function 14, unchanged. Also, each of the sections in the main program which refer to these functions could be removed, further reducing program size. An ultimate size of less than 50K bytes is anticipated. Section 3.1 of this report describes the main program in detail.

2.7 EQUATIONS REFERENCED IN THE REPORT

The following equations are those referenced within this document and are taken from Reference 1. Two identifications are given for each equation; the number as used in this document and the number in the referenced document (in parentheses).

$$T_{\theta+\Delta\theta,i} = \frac{\Delta\theta}{C_i}\left(\sum_{j=1}^{n}\frac{T_{\theta,j}}{R_{ij}} + Q_{\theta,i} - T_{\theta,i}\sum_{j=1}^{n}\frac{1}{R_{ij}}\right) + T_{\theta,i} \qquad \frac{2.7.1}{(4.1)}$$

$$C_i = C_{Si} + (wc_p)_{\theta,i}\,\Delta\theta \qquad \frac{2.72}{(4.8)}$$

$$T_{\theta+\Delta\theta,i} = \sum_{j=1}^{n} \left(\frac{T_{\theta,j}/R_{ij} + Q_i}{1/R_{ij}} \right) \qquad \frac{2.7.3}{(4.11)}$$

$$T_{\theta+\Delta\theta,i} = \frac{1}{(wc_p)_{\theta,i}} \left(\sum_{j=1}^{n} \frac{T_{\theta,j}}{R_{i,j}} + Q_{\theta,i} - T_{\theta,i-1} \sum_{j=1}^{n} \frac{1}{R_{ij}} \right) \qquad \frac{2.7.4}{(6.2)}$$

$$+ T_{\theta,i-1}$$

$$T_{\theta+\Delta\theta,i} = \frac{\Delta\theta}{C_i} \left(\sum_{j=1}^{n} \frac{T_{\theta,j}}{R_{i,j}} + Q_{\theta,i} - \left[\frac{T_{\theta,i}\,(C_i - [wc_p]_{\theta,i}\,\Delta\theta) + \frac{[wc_p]_{\theta,i}\,\Delta\theta}{C_i} \right] \cdot \sum_{j=1}^{n} \frac{1}{R_{ij}} \right. \qquad \frac{2.7.5}{(6.3)}$$

$$\left. + \left[\frac{T_{\theta,i}\,(C_i - [wc_p]_{\theta,i}\,\Delta\theta) + T_{\theta,i-1}\,[wc_p]_{\theta,i}\,\Delta\theta}{C_i} \right] \right)$$

$$T_{\theta+\Delta\theta,i} = \frac{1}{(wc_p)_{\theta,i}} \left(\sum \frac{T_{\theta,j}}{R_{ij}} + Q_{\theta,i} - \overline{T} \sum_{y-1}^{n} \frac{1}{R_{i,j}} + \overline{T} \right) \qquad \frac{2.7.6}{(6.5)}$$

where

$$\overline{T} = \left[\frac{T_{\theta,\ell}\,(wc_p)_{\theta,\ell} + T_{\theta,m}\,(wc_p)_{\theta,m} + \ldots + T_{\theta,n}(wc_p)_{\theta,n}}{(wc_p)_{\theta,i}} \right]$$

and

$$(wc_p)_{\theta,i} = (wc_p)_{\theta,\ell} + (wc_p)_{\theta,m} + \ldots + (wc_p)_{\theta,n}$$

$$T_{\theta+\Delta\theta,i} = T_{\theta+\Delta\theta,j} \qquad \frac{2.7.7}{(6.8)}$$

$$Q_{n,\theta+\Delta\theta,i} = (Q_o)\ (P.F.) \left[\frac{\beta}{\beta\rho} \exp\left\{ \left(\frac{\lambda\rho_\theta}{\beta-\rho_\theta} \right)(\theta) \right\} - \right. \qquad \frac{2.7.8}{(6.12)}$$

$$\left. \frac{\rho_\theta}{\beta-\rho_\theta} \exp\left\{ -\left(\frac{\beta-\rho_\theta}{\ell} \right)(\theta) \right\} \right]$$

$$Q_{\beta+\gamma,\theta+\Delta\theta,i} = 6.22 \times 10^{-2}\ (\theta)^{-0.2}\ (Q_o)\ (P.F.) \qquad \frac{2.7.9}{(6.13)}$$

$$Q_{react,\theta+\Delta\theta,i} = 0.94\ Q_{n,\theta+\Delta\theta,i} + Q_{\beta+\gamma,\theta+\Delta\theta,i} \qquad \frac{2.7.10}{(6.14)}$$

$$Q_{react,\theta+\Delta\theta,i} = Q_{n,\theta+\Delta\theta,i} \qquad \frac{2.7.11}{(6.15)}$$

$$h_i = \beta \left[\left(\frac{N_{Re}}{XM_\infty} \right)^{M_\infty} \right]^a \left(M_\infty \right)^b \frac{1}{T_R - T_\infty} \qquad \frac{2.7.12}{(6.17)}$$

$$h_i = \beta \left[\frac{S \left(N_{Re}/XM_\infty \right) M_\infty}{\left(T_L^1 / T_L \right)^{1.69}} \right] MN_{Pr}^{1/3}\ K \qquad \frac{2.7.13}{(6.18)}$$

3.0 A DESCRIPTION OF EACH SUBPROGRAM

3.1 THE MAIN PROGRAM

The TAP program is constructed in two basic sections: (1) an initialization section where data is read, variables are initialized, flags are set and an initial data print is called for; (2) an iteration scheme where the various functions and tables, used in the problem specifications, are called for according to flags set in the initialization section and where the primary temperature calculations are performed.

The program begins by reading in a title card. Since multiple cases can be run, the program branches to Statement No. 1 at the end of each case. If a card with "TITLE" in Columns 1-5 is not found, additional cards are scanned until such a card is found or until all cards are exhausted. In addition, a flag is examined in Column 6 of the title card. If a "1" is found there, then at the end of the run the temperatures and capacitances are punched on cards suitable as input on a succeeding run.

Since the IBM-360 is a non-zeroed machine, it is necessary to assure that certain critical quantities are set to zero before the calculations begin. Some other quantities must be initialized to numbers other than zero. All this work is accomplished in the first section of programming.

The next section of the program covers the reading of data and the arrangement of the flow path for the program, based on the data read. The arranging is of two different types, both of which are designed to minimize the problem run time.

Based on the function input from subroutine FIN, assignments of statement numbers within the main program are made. These assignments are dependent on which of the functions is used. For any of the functions not used, a section of the main program may be skipped or one of the subroutine calls need not be made.

Based on the input from subroutine TRCIN, the second type of saving can be made. In this case, calculations on certain conductors need not be performed during each iteration. Flags for each conductor are set in entry RFIX of subroutine TRCIN, depending on whether the conductor remains fixed in value during the transient or whether it is variable.

After this work is completed, the temperatures of the zero capacitance nodes is calculated and the information called for in Function 8 is printed out. This information is for time zero in the transient. This action completes the initialization section and serves as the starting point for the iteration scheme.

The first step in the iteration is to save the time step from the iteration just completed so it may be available as information if a print is requested after the iteration is just starting. This occurs at Statement 290. Following this step there occur a series of calls to subprograms which establish the conditions of the nodal network in preparation for the primary temperature calculations.

If tables have been used to describe the relation of one nodal quantity to another, an interpolation is used within the table to establish the current relationship. These calculations are performed only if the user specifies Function 7 in his input. If Function 2 is specified, then the next calculation is the conductance of those conductors where radiation affects the heat transfer. Similarly, use of Functions 4, 6, 1 and 3 would respectively call for calculations of convection conductors, aerodynamic heating, cathode follower, and latent heat information on the specified nodes. The choice of either the Eckert or the Ramo-Wooldridge method of aerodynamic heating is made in the Function 6 input. Use of the cathode follower is to permit the temperature of one node to be set equal to that of another node after each iteration.

After these calculations, a test for the end of the job is made before continuing with the iteration. The flag TOME is zero only during the first iteration and is used to note that iteration. If the problem completion time has not been exceeded, the iteration continues at Statement 205. If the run is complete, then the option to punch the temperature-capacitor cards is checked before returning to Statement 1 to check for the input of the next cast if one exists.

A check is made to be certain that the time step is not smaller than some minimum the user may specify in his input. Then if the current problem time does not exceed the problem completion time, the next iteration step is begun.

The first step in the iteration is to determine the time step (DELTAT). The time constant (RC) of each node is calculated and the minimum noted. This serves as the first estimate of DELTAT. Next a check is made to determine if the user has specified a time step. If he has, it must be smaller than the minimum time constant (to avoid instability), and the lesser of the two numbers is used as DELTAT. The RC minimum may also be multiplied by some fraction to force an even smaller DELTAT on the iteration, thus, guaranteeing more accurate calculations for the relaxation procedure used as the solution technique. If the user does not specify a fraction, 1.0 is used. Finally, the minimum time step acceptable to the user is checked. If DELTAT is less than this, an error message is printed followed by a print of the current output data.

The next calculations called for by the main program are the fluid flow calculations. These are called only if Function 10 was specified in the input. A determination is then made to establish whether a print of the output should occur at the completion of the current iteration. If it should, then the quantity PRTST is set to zero as the flag which is later tested. The next calculations are those for nuclear heating. These are performed only if Functions 5 and 13 were specified in the input.

At this point, the temperature calculations are begun. Equation 2.7.1 is the primary solution equation for the nodal temperatures. Calculations are performed only for nodes with a positive capacitance. The zero capacitance nodes are calculated next after a call to TRA to update the T/R and 1/R sums. Equation 2.7.3 is the one used in the calculations.

The final calculation performed is the one to pass fluid through a series of nodes in one time step. The use of Function 12 causes this calculation to be called. The last calculation step for the current iteration step is to update the problem time.

If the user chooses to check for steady state or equilibrium by specifying Function 14, then subroutine STEADY is called. If the steady-state criterion is met, then the output data is printed immediately. Subroutine TAVG is called if two or more fluid flow nodes are to be averaged into a single node. Function 11 is used to call this subroutine. Following this the PRTST flag is checked to see if a print is required on this iteration. If not the next iteration is begun immediately.

3.2 SUBROUTINE TRCIN

Subroutine TRCIN performs most of the secondary manipulations on temperatures, thermal capcitances and conductances. It is written in three sections. The first section reads in the conductance, temperature and capacitance data. The second section separates the fixed from the variable conductances and calculates the fixed data for permanent storage and later access. The third section calculates the 1/R and T/R sums used in the calculations for temperature change on each iteration step in the main program.

COMMON VARY in this subroutine stores information on the capacitor nodes and conductors which are variable. Most of the integer information is carried as INTEGER*2 to conserve space within the computer core. Several quantities are carried as REAL*8. These are used to permit the calculation of the temperature change with each time step in double precision arithmetic. Those calculations are performed in the main program. The subroutine also makes use of the READ and READ2 entries to subroutine READ. Each of these entries read in three fields of integer data. In READ this is followed by one E15.5 field and in READ2 by two E15.5 fields.

The initial section of the program reads in conductor or resistor data. The I1 field is used to specify the conductor number and the I2 and I3 fields are used to specify the two nodes to which each conductor is connected. The first E field contains the value of the conductance or resistance. The subroutine starts by placing a zero in the locations of all the node numbers appearing in the I2 field to which the conductors are connected. It next checks to see if the input is to be in the form of conductances or resistances. In the past, this program accepted only resistances. It now accepts conductances as well and this choice can be stipulated in two ways. If the first card in the conductor block reads COND in Columns 1-4 then the input is assumed to be in the form of conductances. Otherwise, input is assumed to be in the form of resistances, unless the resistor card is flagged with a C in Column 1. In this case that card only is assumed to be in the form of a conductance. The maximum conductor number is also determined in this section of programming so that future DO loops can stop when the index reaches the maximum conductor number. Except for the first card, all other cards are read (and printed) using the READ subroutine.

An option is available in reading the conductor cards which can significantly reduce the card input. If the node numbers in both the I2 and I3 fields are negative, the program will read the next card and internally generate all the intermediate sequential conductor and node numbers assigning the same conductance or resistance value, which appears on the last card, to each generated card. If only the I2 or the I3 field is negative, then the same thing occurs except the positive I2 or I3 field has its number remain constant during the internal generation. The last card in the conductor block contains only a -1 in the I1 field.

The conductor data are followed immediately by cards containing information on the thermal capacitances and the initial temperatures at each of the nodes. Input is read using the READ2 subroutine and is in the form of three I fields and two E15.5 fields. The node number is written in the first I field, the initial temperature is written in the first E field and the thermal capacitance is written in the second E field. If a -1 is inserted in the I2 field, it is possible to generate nodes internally in much the same manner as was done in the conductor input. After the card containing the -1, in the I2 field, the last card of a sequence of nodes is input. The subroutine internally generates the intermediate nodes, giving the same temperature and capacitance as appeared on the last card, to each. Any initial temperature which is input as zero in the temperature-capacitor block is given a value of 10^{-4} to facilitate a check of conductors and nodes to see that none of them remain unconnected. The last card in the temperature-capacitor block contains only a -1 in the I1 field. The maximum node number is also sought in this section of the programming so that future DO loops can stop when the index reaches that maximum number. After completion of the temperature-capacitor reading section, control is returned to the main program.

Subsequent to this, the check on unconnected conductor and nodes is performed. Two small DO loops perform this function. The first loop finds the two nodes to which each resistor is connected and notes whether the temperature of that node is other than zero. If not an error message is printed. At the same time it temporarily assigns a value of 1.0 to the 1/R sum (RI) of each node. The second DO loop then checks each node with a non-zero temperature to ascertain if RI for that node is also non-zero. If RI is

zero, and if the capacitance is non-negative, an error message is printed noting a node which is not connected to any conductor. The exception of the negative capacitance node permits the use of a node as a heat sink or as a leading node in one of the fluid flow routines.

The next section of the subroutine is entry point RFIX which is called from the main program prior to performing any temperature calculations (immediately before Statement No. 108). The purpose of this section is to distinguish between the variable and fixed resistors and also those nodes which are attached to variable resistors. The 1/R sum must be calculated for each node, to be used later in calculating temperature changes during each iteration. That portion of this sum which is from fixed resistors need be calculated only once during the program. This set of calculations is performed and the values stored as RIFIX for each of the nodes to which a fixed conductance (resistance) is attached. The initial value of the 1/R sum is set equal to the fixed portion of that sum. The variable portion is added in the TRA section of this subroutine. Control is returned to the main program when these operations have been completed.

The final section of the subroutine begins at entry point TRA. In this section the quantities RI and TR are calculated for use in the main program. These calculations are performed twice; once to calculate temperature changes of all nodes with a positive capacitance and the second time to permit calculation of the zero capacitance nodes after the temperature of the surrounding positive capacitance nodes have already changed. The first entry is from Statement No. 205 in the main program while the second is from 255 of the main program. The only calculations which must be performed on the second pass are for TR. The argument IPASS directs the subroutine to perform only the necessary calculations.

If none of the conductors are variable, then it is not necessary to recalculate the RI's. Under these circumstances, the calculations at Statement Nos 105 and 122 are skipped. If IPASS is 2, then the RI also need not be calculated since neither the conductance nor RI are modified between the first and second entries to TRA. Consequently, the calculations at Statement No. 105 are skipped and control is directed to Statement No. 130 where RI is not

calculated and where only the zero capacitance nodes are considered when the TR calculations are repeated.

If IPASS is 1, then the RI's are reinitialized to their fixed portion. The TR's are initialized to zero and then the remaining RI and TR calculations are performed. The additional RI calculations need only be done on the variable resistors. The TR's are calculated for all nodes. Control is then returned to the main program.

3.3 SUBROUTINE FIN

Subroutine FIN is called only once from the main program immediately after the call to TRCIN. The sole purpose of this subroutine is to read in the function data which give the program its flexibility. Some of the functions recently placed in the program will be new to users familiar with older versions of TAP. Persons wishing to provide additional flexibility for the program can readily do so by creating new functions and factoring them into the calculation stream of the main program at the appropriate locations.

There are currently 14 functions in the program. Since the data read into these functions in FIN is generally used in one or two other locations, this information has been placed in a series of commons, each tied to its own function. Data for Function 1 is stored in COMMON FUN1, Function 2 is FUN2, etc. In addition, COMMON VARY contains data pertaining to those conductors which are variable. Flagging this information saves recalculation of those conductances which are fixed throughout the calculation of the transient. Much of the function data contains integer information, most of which is designated INTEGER*2 to conserve space in the computer core.

The FORMAT statements are listed separately at the front of the subroutine since some of them are referenced from more than one location. Also, at the front of the subroutine several quantities are initialized in anticipation of use in the input of various functions. Data are read in by making use of the READ and READ2 subroutines. The data format is three integer fields ending in Columns 5, 10 and 15 and one E15.5 field in READ and two E15.5 fields in READ2.

The active portion of the subroutine begins by reading a card and checking the first integer field for a function number. If a zero or negative number is found, control is returned to the main program. At the end of the data for each function a -1 in the first integer field signifies the end of that function. Control is then transferred to the initial read statement and the next function number is sought. Again, if a zero or negative value is found in the first integer field, control is returned to the main program. If a zero or -1 card immediately follows the -1 card at the end of the temperature-capacitor data, the program prints out an appropriate error message since Functions 8 and 9 must be used for each problem. If two successive -1 cards or a -1 card followed by a zero card is found within the function blocks, then control is returned to the main program. A flow chart of this subroutine appears in Appendix A.

Function 1 accepts data on cathode follower nodes. The first card of this data contains a 1 in the I1 field. The I2 field contains the number of the following node and the I3 field contains the number of the leading node on this and every succeeding card. A total of 25 cathode follower nodes are permitted. Calculations for this function begin at Statement 321 of the main program. In these calculations, the temperature of the following node is set equal to that of the leading node before each time step in the transient. The last card in Function 1, as in all other functions, contains only a -1 in the I1 field.

Function 2 accepts data on as many as 250 conductors for which radiation is the mode of heat transfer. The first card contains a 2 in the I1 field. The I3 field contains the conductor number and the first E field contains the value of K as defined on page 20 of Reference 1. The value of the radiation conductor is calculated at the start of each time increment starting at Statement No. 301 of the main program. An additional option is available in Function 2. If a minus is inserted before the conductor number in the I3 field, the subroutine will read the next card and assign the K value of that card to all conductor numbers beginning with the negative number and ending with the number on the card just read. Thus, if -49 and 59 appear in the I3 field of two successive cards, Conductors 49 through 59 will be assigned the K value that appears on the 59 card. Then if a thermal model contains a number of radiation conductors with the same K value, and the user numbers them consecutively, all

but the first and last cards may be omitted. The last card must contain only a -1 in the I1 field.

Function 3 accepts up to 50 pieces of data on those nodes for which latent heat data must be considered. All data are input in sets of two cards. The first card contains a 3 in the I1 field. This is also the first card of the first set of two. The I3 field of the first card contains the node for which the latent heat information is pertinent. The first E field contains the temperature at which the solid-liquid phase change occurs and the second E field contains the total amount of heat required for the node to undergo this change of phase. The second card of the set contains information only in the two E fields. This is the temperature and total heat required by the node to undergo the liquid-vapor phase change. The latent heat information is calculated before each time increment starting at Statement No. 326 of the main program. The last card contains only a -1 in the I1 field.

Function 4 accepts as many as 100 pieces of data on those conductors for which variable convection is the mode of heat transfer (constant convection conductors are input in subroutine TRCIN). The first card contains a 4 in the I1 field. This and all succeeding cards contain the conductor number in the I3 field, the exponent used in Equation 5-4 of Reference 1 is contained in the first E field and the area given in that equation is contained in the second E field. The variable convection conductors are calculated at the start of each time increment, beginning with Statement No. 306 of the main program. The last card contains only a -1 in the I1 field.

Function 5 accepts data for the reactor heating model currently in the program. The first card contains a 5 in the I1 field and the value of Q_o as used in Equations 6-12 and 6-13 of Reference 1, is contained in the first E field. As many as 100 succeeding cards contain each node number in the I3 field and the power factor of the node (as described in the above-mentioned equations) in the first E field. The card following this data contains, in the I1 field, the number of the table where reactivity change vs time is given. The heat input from these nodes is calculated prior to the temperature calculations of each time increment at Statement No. 235 of the main program. The last card contains only a -1 in the I1 field. It should also be noted that Function 13 must be used whenever Function 5 is used.

Function 6 accepts data on the aerodynamic heating functions. The first card contains a 6 in the I1 field, a +1 in the I2 field if the Ramo-Wooldridge method is to be used (blank or zero if the Eckert method is used), a +1 in the I2 field if B is not 1.0 as described on page 46ff of Reference 1. Successive information appears on sets of two cards; up to 25 sets may be provided. The first card contains the node number in the I3 field and the value of K from Equation 6-16 of Reference 1 is contained in the first E field. The second card is used only if B is not 1.0. The I3 field contains a +1 if the node is a top surface (a zero or blank is used if it is a bottom surface), and the first E field contains the value of α, the local wing subtended angle. The last card contains only a -1 in the I1 field. The calculations for aerodynamic heating begin at Statement No. 311 of the main program. It should be noted that these calculations require input in several tables and also some input into Function 9.

Function 7 accepts up to 250 pieces of data which identify the change of one variable as a function of another. The first card contains only a 7 in the I1 field. Succeeding cards contain the dependency information. The I1 field contains the number of the dependent variable, the I2 field contains the number of the independent variable, the I3 field contains the table number in which the dependency is specified and the first E field contains the multiplying factor of the resultant if it is different than 1.0. The last card contains only a -1 in the I1 field. The arbitrary function interpolations are calculated at the start of each time increment beginning at Statement No. 291 of the main program.

Function 8 accepts as many as 700 pieces of data on the print specifications. It is possible to print out the value of any conductor or resistor number or the temperature, thermal capacitance or heat input to any node. The first card contains an 8 in the I1 field. The I2 field contains the class of variable to be printed and the I3 field gives the number of the variable to be printed. An option is also included whereby only the first and last cards of a consecutive sequence of one output variable need be included. The variable number on the first card is the negative of its true value. Thus, for Variable Class 2 (temperature), to print nodes 1 through 100 only two cards need be included; a 2 in the I2 field of both cards and -1 in the first card and 100

in the second in the I3 field. The last card contains only a -1 in the I1 field. The print specifications are used beginning at Statement 400 in the main program.

Function 9 accepts data on a series of problem constants used at various locations in the main program. The first card contains only a 9 in the I1 field. The problem constant number is given in the I3 field and information pertaining to the problem constant is given in the two E fields. Constant 1 establishes the print interval and is used starting at Statement No. 231 in the main program. The print interval may be altered during the course of the transient. If the same print interval is desired during the transient, the 1 in Column 15 is used with the print interval specified in the first E field. If the print interval is to be varied, the time at which the print interval is to change is entered in the second E field. Up to 5 different print intervals may be specified in this way. Constant 2 is used to over-ride the time interval. A 2 is written in Column 15 and the two E fields are specified in the same manner as Problem Constant 1. If only one over-ride time interval is to be used throughout the transient, then only one card is used with a 2 in Column 15 and the interval given in the first E field. Problem Constant 2 is used, starting at Statement No. 223 in the main program. Program Constant 3, given in the first E field, is a multiplying factor with a magnitude less than 1.0. The factor modifies the time interval between iterations, to guarantee more precise answers within the stability criterion. It is used in Statement 227 of the main program. Problem Constant 4 is the problem completion time and is used in Statement No. 335 of the main program. Problem Constants 5-8 are used in the aerodynamic heating calculations previously described. Problem Constant 9 is the initial time of the transient and is used in Statement 200 of the main program. Problem Constant 10 is the minimum allowed time interval. It is used in Statement 228 of the main program. The last card in Function 9 contains only a -1 in the I1 field.

Function 10 accepts data on heat transfer by incompressible fluid flow. The first of as many as 250 cards contains only a 10 in the I1 field. The input on the following cards contains the table number, where wc_p vs time is found, in the I1 field, the following node number in the I2 field, the leading node number in the I3 field, the wc_p of the following node in the first E field, and the time at which the following node becomes filled with the incompressible fluid

in the second E field. Flow in Function 10 and other functions is from the leading to the following node. The time at which a node becomes full is usually zero and can be left blank if desired. The existence of this quantity permits more accurate solution of the problem where fluid is flowing into a previously empty region. If this number is other than zero the thermal capacitance of that node should be specified in the capacitance input block as a 0 or -1 node. The last card in the Function 10 input contains only a -1 in that I1 field. The option to use only the first and last cards of a sequence of nodes is also available in Function 10. A minus is placed before the leading node (the I3 field) of the first card. The program automatically sequences both the leading and following nodes, keeping all other information constant, through the node numbers found on the card representing the end of the sequence. Function 10 is used in the main program at Statement No. 230.

Function 11 accepts up to 50 data cards which permit the merging of two or more fluid streams into one node. The first card contains only 11 in the I1 field. Succeeding cards contain the data. In the I2 field is the node number into which the fluid is flowing. The I3 field contains the node number of one of the nodes being mixed and the I1 field contains the table in which the wc_p of that node is described as a function of time. The last card contains only a -1 in the I1 field. Function 11 is used immediately following the completion of all calculations of temperature change during each time increment at Statement No. 280 in the main program.

Function 12 accepts data which permits the passage of fluid through a series of nodes in one time interval. The input in Columns 1-15 is identical to that of Function 10. The first E field contains the solid portion of the node capacitance. Function 12 also permits entry of the first and last cards of a sequence by inserting a minus before the leading node of the first card. The leading and lagging nodes are sequenced and all other information is kept constant in a manner identical to the use of Function 10. The last card in Function 12 contains only a -1 in the I1 field. Function 12 is used at Statement No. 266 in the main program.

Function 13 accepts data on the reactivity temperature feedback to the reactor calculations as well as data on the use of a deadband controller. The

first card contains only 13 in the I1 field. The next three cards contain the node number and the reactivity coefficient of the three nodes which it has been assumed adequately describe the temperature feedback to the reactor. If no deadband controller is used, the next card contains a -1 in the I1 field. If a deadband controller is used, the next card contains the node to which the deadband characteristics are applied in the I3 field, the reactivity insertion increment is given in the second E field. The second deadband card contains the temperature to which the critical node is being compared in the first E field and the deadband around this temperature which must be exceeded before a reactivity insertion is applied in the second E field. These quantities are used in the reactor heating calculations (Function 5). The last card contains a -1 in the I1 field.

Function 14 accepts data to permit the early completion of a run if steady state has been reached. The first card contains 14 in the I1 field, and the relative error per time increment which is considered sufficient to determine steady state in the first E field. It is also possible that a series of steady-state conditions could exist. For each succeeding steady-state condition, a card is added. The I1 field contains the card number (up to 20 may be used) and the first E field contains the time to which the problem will automatically be advanced. The last card contains -1 in the I1 field.

3.4 SUBROUTINE TABIN

Subroutine TABIN is called from the main program immediately following the call to FIN. Its purpose is to read in the data presented to the program in the form of tables. The subroutine calls the READ2 subroutine to read the data as presented in three I fields and two E fields. COMMON VARY is used to collect and pass data on those conductors which vary during the course of a transient. COMMON FUN7 serves the same purpose since the only way conductors could be varied in the form of tables is through the use of Function 7 and its COMMON FUN7.

The subroutine begins by reading a card containing the table number in the I1 field, the class of independent variable in the I2 field, the class of dependent variable in the I3 field, the value of the independent variable in the first E field and the value of the dependent variable in the second E field. A check is made to see if the dependent variable is Type 1. If this is true,

then the appropriate conductor number is obtained from the data in FUN7 and is stored in VARY so that only calculations on these variable conductors need be performed.

Successive cards are now read and these contain the independent variable in the first E field and the dependent variable in the second E field. These data (up to a total of 52 cards including the first) are read in until the graph of the function has been described in tabular form. All tabular data are later searched by a linear interpolation routine when used in the program calculations. The last card at the end of each table must contain only a -1 in the I1 field.

3.5 SUBROUTINE READ

Subroutine READ is used for the purpose of reading and then printing the input to the program which has a format of three I fields and one E field. After this information is read, it is passed back to the calling program through the arguments in the calling sequence. This subroutine is called from the conductor, resistor input section of TRCIN and from many locations in FIN. The first column could contain the letter C if used in subroutine TRCIN, to designate that the value in the E field is a conductance rather than a resistance. If a C is found, then KFLAG is set to zero and passed back to TRCIN through COMMON FLAG for appropriate notation. KFLAG is not used in subroutine FIN. The format contains 50 columns of Hollerith information to permit the user to include comments on his input cards.

Entry READ2 is used for the purpose of reading and then printing the input to the program which has a format of three I fields and two E fields. The subroutine is called from the temperature-capacitor input section of TRCIN, from several locations in FIN and from TABIN. The information is read from cards and passed back to the calling program through the arguments in the calling sequence. The format contains 35 columns of Hollerith information to permit the user to include comments on his input data.

3.6 SUBROUTINE FLOW

Subroutine flow is divided into two parts. The first part is called from the main program at Statement No. 229. Its purpose is to account for the transport of heat by incompressible fluid flow when the heat transfer coefficient to the adjacent walls is well known. Input to this section of the subroutine is through Function 10 and any tables specified in that function. This information is carried in COMMON FUN10. The second part of the subroutine begins at entry FSTFLO and is called from Statement No. 265 in the main program. Its purpose is the same as for the first part of the subroutine, except that the fluid moves through several nodes in one time increment (DELTAT). Input to this section of the subroutine is through Function 12 and any tables specified in that function. This information is carried in COMMON FUN12.

The first part of the subroutine begins by initializing error flags. Then the current wc_p from each of the tables referenced in Function 10 is calculated. This calculation is performed by a linear interpolation using function subprogram ENTERP. The ratio of the minimum node capacitance to the current wc_p value is calculated for each table referenced. The units of this ratio are time. If this ratio is less than DELTAT, then DELTAT is adjusted to be equal to the ratio. A discussion of this point can be found in Section 6.4 of Reference 1. At this point, the calculations are performed to find the temperature of the following nodes indicated in the Function 10 input. If a Type II (positive capacitance) node is indicated, the temperature of the fluid remaining in the node and the fluid entering are averaged. This temperature is then used in the temperature calculations in the main program as indicated in Equation 2.7.4. If the node is a Type I (zero capacitance) node, the following node is set equal to the leading node. Calculations are then later performed according to Equation 2.7.5.

Another test made in this section is whether or not to perform the flow calculations on any given node. The Function 10 input permits calculations on any fluid node to be omitted until a specified time in the transient. This permits simulation of the condition where a fluid node is initially empty and has fluid introduced during the course of the transient. Such a case would exist for the initial transient when a boiler is first filled or other similar circumstance.

A stability check is also made in this subroutine following Statement No. 30. If both the RC product of any of the flow nodes is less than the minimum RC product for the remainder of the nodal network and DELTAT is less than 1 for two successive iteration, this is considered a fatal error and the calculations are terminated. If the stated conditions were present, then on each successive iteration the DELTAT would decrease until it causes an underflow condition in the computer core. This condition can only exist on a Type I node.

The second part of the subroutine begins at ENTRY FSTFLO. On the first pass through the subroutine, the temperature of each node from the previous time step (TEMP) is initialized. In succeeding passes, the program initializes error flags unique to this section of programming. First, the wc_p referenced in each of the the tables named in Function 12, is calculated. Then the capacitance of each of the following nodes is calculated according to Equation 2.7.2. The stability of each node is checked according to the same criteria used in the first part of the subroutine. If the node passes the stability criteria, the temperature of each node is calculated according to Equation 2.7.7.

3.7 SUBROUTINE ENTERP

Function subprogram ENTERP is a linear interpolation routine and is called from a number of locations throughout the program. It searches the data within the table being referenced and performs the requested interpolation. The table number is available through common TABNO. The arguments to the subprogram are the argument (ARG) and the value of the first number in the table of interest (TAB).

A check is first made to see if the table has a constant dependent variable. This is denoted by a non-zero value in the second position of the table. In this case the constant is passed back to the calling routine as the result of the function calculations.

If this is not true, the subroutine proceeds to a search of the table to calculate the result. If the independent variable in the table increases with higher table locations (as will be true for most cases), then the search proceeds until the independent variable exceeds or is equal to the argument. If it is equal, then the corresponding dependent variable is passed back as

the result. Otherwise, a linear interpolation, between the points that bracket the argument, is performed.

If the table describes a periodic function, then the first location in the table gives the period. Periodicity is tested and appropriate modifications to the argument made if the test is positive.

If at any time it is found that the argument is less than the lowest independent variable in the table or greater than the highest independent variable, then an error message is printed out giving the argument and the table number in which the search was taking place. This is a fatal error condition and results in an immediate termination of the job.

3.8 SUBROUTINE TAVG

Subroutine TAVG is called from Statement No. 281 in the main program. It is used to average the temperature of two or more fluid nodes which join to form a common node. Input to this subroutine is through Function 11 with the data being stored in COMMON FUN11. The subroutine first sets the sum of the capacitances (CSUM) and the sum of the capacitance-temperature product (CTSUM) to zero. An error flag is initialized before the calculations proceed.

The calculations are performed according to Equation 2.7.6. To perform the calculations the inlet node (INNODE) and the joining node (NUNODE) are noted along with any table which carries data of wc_p vs time. When NUNODE is the same as that of the previous pass through the DO loop, then CSUM and CTSUM are increased by the appropriate amount. If NUNODE is changed from the previous pass, then the capacitance and temperature of node NUNODE are calculated. A stability check is made, as in subroutine FLOW, and if the problem is unstable an error message is printed and the solution process stopped. It is necessary for the stability check to fail on two successive passes through the subroutine before the error is noted. After these calculations have been completed, the next joining node is noted and further calculations performed until all the Function 11 data have been analyzed. Control is then passed back to the main program.

3.9 SUBROUTINE HEATIN

Subroutine HEATIN is called from the main program at Statement No. 235. Its purpose is to perform nuclear heating calculations using a simplified reactivity model as the driving force for thermal calculations. Input for this subroutine is through Functions 5 and 13. This nuclear heating model has been added to satisfy the requirements of SNAP-8 thermal transient analysis. It would be possible to replace this heating model simply by replacing this subroutine and the arguments to it, by altering Functions' 5 and 13 inputs, and by altering COMMON FUN5 and FUN13 in the main program, in subroutine FIN and in this subroutine.

The subroutine starts by calculating the predetermined change in reactivity if any exists. This is done by interrogating the table specified in the Function 5 input, which gives reactivity input as a function of time.

A check is next made to determine whether a deadband controller is used as part of the analytical model. If it is not, control is passed to Statement No. 10 in this subroutine. Otherwise, a check is made to see if the temperature of the node specified as NDEADB exceeds the base deadband control temperature by more than the allowable deadband limit. If it does not, the heating calculations are continued. If the temperature of node NDEADB is outside the deadband limits, a check is made to determine if the reactivity change permitted by the deadband controller has been made within a time period specified in the input to Function 13 as DBWAIT. If not the proper reactivity adjustment is made. If the last controller change has been too recent the heating calculations continue at Statement No. 10.

At Statement No. 10, the first calculation is the total reactivity change driving the reactor. This is the sum of temperature reactivity feedbacks from three lumped nodes, the deadband contribution and the predetermined reactivity change. The calculations proceed according to Equation 2.7.8. (This assumes that the reactor is nearly critical during the calculations.) Should the reactor be in a prompt critical state, the calculations are stopped by branching to Statement No. 910.

The exponents used in the referenced equation are next calculated and tests are made on these numbers to avoid overflows in the computer. A DO loop

is then entered to calculate the heat generated in each node. It is assumed that the basic reactor operation is at some power level Q_o. The beta and gamma heating is some fraction of this power level. It is further assumed that beta and gamma heating need be considered only in the case of a shutdown and that if a shutdown occurs it will start at time zero. Thus, if the power is any fraction greater than 6% of its original level, then 6% of the power is assumed to be from the decaying beta and gamma heat. When calculations have been completed for each of the nodes specified in the Function 5 input, control is returned to the main program.

3.10 SUBROUTINE STEADY

Subroutine STEADY is controlled by input from Function 14 and is called following Statement No. 270 in the main program. Its purpose is to terminate the execution of the program once equilibrium conditions occur without waiting until the problem completion time specified in Function 9 has been reached. Use of this subroutine by choosing Function 14 can present a significant monetary saving since it is often quite difficult to accurately estimate the time at which equilibrium is reached. An overestimation results in the use of excess computer time. An underestimation means wasted time because the computer run must be resubmitted.

The error criterion on which the assumption of equilibrium is based is fractional change in temperature per unit of time. The temperature of each node (T), the maximum number of nodes (MAXNO), and the time increment (DELTAT) are passed to the subroutine as arguments. The argument KEY is determined in the subroutine and passed back to the main program. If its value is 1, then equilibrium has been attained.

The subroutine first sets KEY to 1 assuming that equilibrium will have been reached. It then compares the fractional change in the temperature of each node in the latest time step (DELTA) with the error criterion given. If DELTA is greater than the error criterion (ERROR) then KEY is set to zero and the search ended for this time step. If DELTA is less than ERROR, the search continues through the remaining nodes. Before control is returned to the main program, the temperature of each node is saved as TSAVE to be used on the next iteration to determine the fractional temperature change in this subroutine.

3.11 SUBROUTINE LAT

Subroutine LAT is called from Statement No. 327 in the main program. Its purpose is to correctly follow the temperature of any node which could go through a phase change. Temperatures of these nodes are calculated normally in the program and then modified as necessary in this subroutine. The modification occurs when a node crosses a phase change temperature boundary. When this happens the subroutine keeps the nodal temperature at the phase change temperature until sufficient heat has been added to or taken from the node for it to again change temperature in its new phase. It should be noted that any node which can undergo a phase change must also have its thermal capacitance specified as a function of temperature in Function 7. Input to the latent heat subroutine is through Function 3 in subroutine FIN.

The subroutine is entered separately for each node which could undergo a phase change. The determination is first made whether the node is currently undergoing a phase transition (QDEL=0). If not and if neither the current temperature nor the temperature during the previous iteration was at a phase transition temperature, then the current temperature is noted as TPREV so that a similar comparison with the previous temperature can be made on the next iteration. If a phase change is taking place, the change in heat to the node during the current iteration period is noted. If it is sufficient to change the node from the transition temperature then QDEL is reset to zero and the node is again permitted to undergo temperature changes. During each pass through the subroutine both the upper and lower phase transition temperatures are checked (PHT1 and PHT2, respectively).

3.12 SUBROUTINE QECK

Function subprogram QECK is called immediately following Statement No. 311 in the main program. Input for this subroutine is through Function 6 and through some of the problem constants specified in Function 9. The purpose of the subroutine is to calculate aerodynamic heating using the Eckert equation (Equation 2.7.13).

Most of the information used in the equation is contained in tables as noted in the description of subroutine FIN. The flow path through the subroutine is simply one of interpolating in each table using function ENTERP. If

errors are encountered in any of the interpolations, an error flag is set and returned to the main program. At that point the work on the problem is stopped and data for another problem would be read in if it exists. After the proper values have been interpolated from each of the tables they are used to calculate QECK and this value is returned to the main program as heat input for the node specified.

3.13 SUBROUTINE QRW

Function subprogram QRW is called immediately following Statement No. 316 in the main program. It is used to calculate aerodynamic heating using the Ramo-Wooldridge equation (Equation 2.7.12). Input is through Functions 6 and 9, just as for function QECK.

Calculations proceed in the same manner as for function QECK. The information used in the Ramo-Wooldridge equation is obtained by interpolating in the tables described in subroutine FIN. If errors are encountered calculations on the problem are stopped. The appropriate values are then used to calculate QRW and this value is returned to the main program as heat input for the node specified.

4.0 FORTRAN VARIABLES AND THEIR USE IN THE PROGRAM

Variable	Description
C	Thermal capacitance of the subscripted node
Q	Heat input to the subscripted node
T	Temperature of the subscripted node
CO	Problem constants specified in Function 9 of the input data
FD	Floating point data in the first floating point field of the input cards (Col. 16-30)
I1, I2, and I3	Integer data in the first, second, or third integer field of the input cards (Col. 1-5, 6-10, and 11-15, respectively)
KC	Node specified as a cathode follower in Function 1
KR	Conductor specified as having radiant heat transfer in Function 2
QO	The base heat output of the reactor, used in the nuclear heating routine
RC	The RC product of the subscripted node; calculated as the capacitance of the node divided by the sum of the conductances surrounding the node
RI	The sum of the conductances of the subscripted node
TR	The temperature of the subscripted node divided by the sum of the conductances
ADD	Multiplier of the print frequency which determines the time at which output is printed
AER	The value of K in Equation 6-16 of Reference 1
ARG	The independent variable passed to function ENTERP as the argument
EKR	The coefficient K_{ij} used in radiant heating calculations as described in Equation 5-5 of Reference 1 ($K_{ij} = \sigma\text{-}FA_{ij}$)
F14	A flag set to 1 if function 14 is to be used
IKF	A counter to determine the number of pieces of data used in Function 7
IPH	The node for which latent heat calculations are to be performed

Variable	Description
IPK	A counter to determine the number of pieces of information to be printed for each printout
I2V	Node number in the I2 field to which a conductor is attached
I3V	Node number in the I3 field to which a conductor is attached
KEY	A flag set to 1 if steady state has been successfully achieved
MIX	A counter to determine the number of pieces of data used in Function 12
NEW	The following node as designated in the fluid flow input
QCH	The total heat accumulated in a node which is undergoing phase transition
RHO	The temperature coefficient of reactivity of the node specified in the I3 field in Function 13
TAB	The table passed to function ENTERP for evaluation
TYM	The time at which the program $\Delta\theta$ currently being used is no longer used
TYP	The card field on the first data card of a run which must read "TITLE"
WCP	The WC_p of the subscripted table
ACON	The area for the subscripted convective heating conductor
COND	The conductance of the subscripted conductor
CSUM	The sum of the fluid capacitances flowing into a single node; used in subroutine TAVG
DBGO	The time at which the dead-band reactivity controller is again permitted to be moved
DELK	The δk of the reactor in the nuclear heating calculations
IAER	The node for which the aerodynamic heating calculations are being performed
IAF2	The node or conductor number of the dependent variable in the arbitrary function input
IAF3	The node or conductor number of the independent variable in the arbitrary function input

Variable	Description
IAF4	The table number in which the arbitrary function is described
ICON	The conductor number described in the free convection function input
IERR	An error indicator set to 1 if either subroutine FLOW or TAVG have a mathematical instability
IFUN	An indicator set equal to various function numbers to indicate an error in that function
IPHK	A counter to indicate the number of pieces of data used in Function 3
IPR1	Specification of the type of output desired for the node or conductor number on that input card
IPR2	The node or conductor number for which output is desired
IRAD	A counter to indicate the number of pieces of data used in Function 2
IRB1	A counter to indicate the number of pieces of data used in Function 5
ITAB	The table number and classes of variables described in the table input
KDEP	The dependent variable type referenced when referencing a particular table
KIND	The independent variable type referenced when referencing a particular table
KNEW	The node number of the leading node as used in subroutine FLOW
LNEW	The following node number in the input for the fast fluid flow
NODQ	The node number referenced in the nuclear heating calculations (subroutine HEATIN)
PHH1	The amount of heat necessary for the referenced node to pass through the solid-liquid transformation
PHT1	The temperature at which the solid-liquid phase transformation occurs for the referenced node
PHH2	The amount of heat necessary for the referenced node to pass through the liquid-vapor transformation
PHT2	The temperature at which the liquid-vapor phase transformation occurs for the referenced node
PRNT	The time at which the next output is to be printed

Variable	Description
QDEL	The amount of heat stored or lost by the referenced node during the time it was undergoing a phase change
TEMP	The temperature saved from the last iteration in the fast fluid flow calculations
TIME	The problem time (used in subroutine LAT)
TNEW	The temperature of the leading node as used in the fluid flow calculations
TOME	A flag set to zero at the start of the problem to denote the first iteration; on the first iteration some calculations are performed for utilizing values and not repeated, other calculations are skipped because these initializations have not yet taken place; after the initial iteration TOME is set to 1.
TZME	The problem time
ALLOC	The local wing subtended angle in the aerodynamic heating calculations
CFMIN	The minimum fluid capacitance of each table referenced in the Function 10 input
CTSUM	The sum of the capacitances times the temperatures of the fluid nodes being merged in subroutine TAVG
DBTOT	The total dead-band controller contribution to the reactivity change, as used in the nuclear heating calculations
DELKC	The predetermined reactivity change in the nuclear heating calculations as determined from the referenced table
DELTA	The calculations of the percentage temperature change per unit time in comparing whether steady state has been attained
ERROR	The percent rate of change per unit time of the most rapidly changing node which is used as the criterion of attaining a steady state condition
EXCON	Exponential constant used in the convection conductor calculations and input in Function 4
FIAF	A multiplying factor used in any of the arbitrary function designations
IAERK	A counter to indicate the number of pieces of data in Function 6
IAER1	A number in the I2 field of the aerodynamic heating input; if zero, the Ramo-Wooldridge calculations are performed - if one, the Eckert method is used

Variable	Description
IAER2	A number in the I3 field of the aerodynamic heating input; if zero, then β is a function of α - if one, the functional relationship does not exist
ICALC	A flag set in the main program to determine if temperature calculations are performed on all nodes during that iteration or only on some designated nodes
ICATH	A counter to indicate the number of pieces of data in Function 1
ICONK	A counter to indicate the number of pieces of data in Function 4
IDELK	Table number in which is described the predetermined reactivity change versus time in the nuclear heating calculations
INNOD	The node number of one of the fluid flow nodes being averaged in a common node (used in subroutine TAVG)
IPASS	A flag to denote the first or second pass through Section TRA of subroutine TRCIN during the iteration scheme
IRVAR	An indicator which is set equal to the conductor number if the conductor is variable; it permits recalculation of only variable conductors during the transient
ISTEP	A counter which helps point to the data on frequency of printed output
IZAER	A flag to determine if the aerodynamic heating is for a top surface (=0) or a bottom surface (=1)
JTABL	The table number in which is stored the wc_p versus time information for the fluid flow node used in the averaging scheme of subroutine TAVG
KEY10, KEY11, and KEY12	Flags set in the use of Functions 10, 11, or 12 which denote an instability in the use of the data from one of those functions
KLEAD	The leading node in the fluid flow calculations
LLEAD	The leading node in the fast fluid flow calculations
MAXNO	The maximum node number used in the problem
MINND	The node which has the minimum RC product
NBASE	A node which is used as a reference for the temperature feedback in the nuclear heating calculations

Variable	Description
NODEQ	One of the node numbers input for which nuclear heating calculations are performed
NSTEP	A counter which helps point to the data on time steps chosen for the iteration scheme
NUNOD	The node number into which two or more fluid nodes are being combined and their temperatures averaged
PRINT	Space reserved in the main program to permit printing of any temperature, capacitance, conductance, or heat flow, or a node or conductor by addressing the proper location within PRINT
PRTST	A cumulative counter used to test when in the transient printed output is requested
PRUNT	The area in which the numbers to be printed are stored before the print operation occurs
QBETA	The beta-gamma heating of the subscripted node as used in the nuclear heating calculations
RCMIN	In minimum RC product
RIFIX	The 1/R sum for the fixed conductors
TABLE	The location within the tables where a particular functional relationship is described
TBASE	The temperature of node NBASE at which reactivity feedback to the reactor is zero
TFLAG	A flag set to 1 after the first pass through Section TRA of subroutine TRCIN; if all the capacitors are non-zero, the flag remains set and the second pass through TRA is skipped
TPREV	The temperature of the node used in the latent heat calculations on the previous iteration
TSAVE	The temperature of the subscripted node on the previous iteration as used in the determination of the attainment of steady state
WCPDT	The current value of $wc_p dt$ for the subscripted table
ADTIME	The time to which T2ME is advanced after a steady state condition has been reached
CFLUID	The capacitance of the subscripted following fluid flow node
CSØLID	That portion of a following fast fluid flow node which is due to the surrounding walls

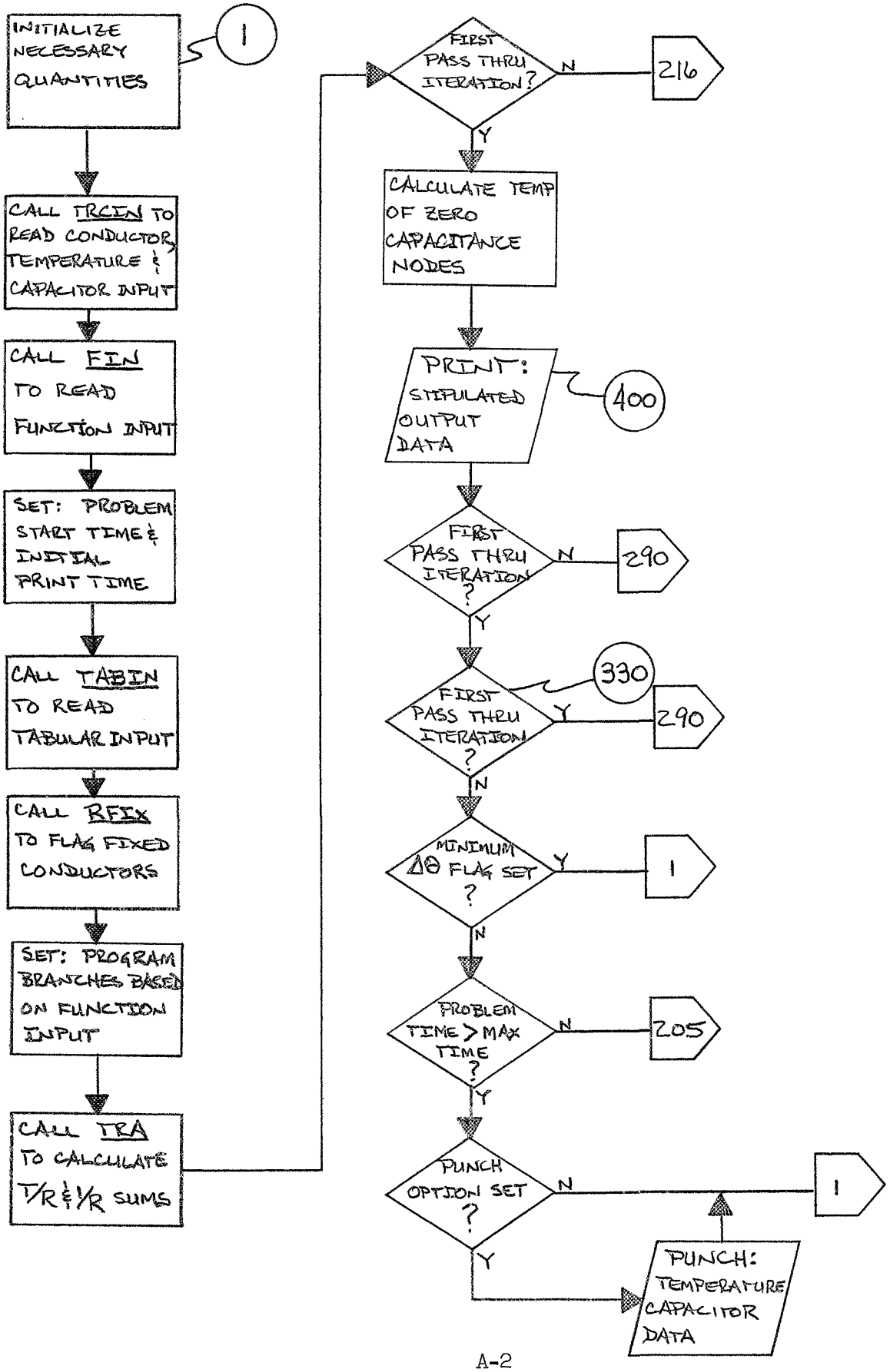
Variable	Description
DBWAIT	The minimum time after the movement of the dead-band feedback controller before the controller can be moved again in the nuclear heating calculations
DELKDB	The reactivity change which occurs on each movement of the dead-band controller
DELTAT	The time step used in the current iteration
DELTDB	The dead-band within which a temperature change is permitted without causing activation of the dead-band controller (the limit is $\pm$DELTDB)
FULTIM	The time at which one of the fluid flow nodes becomes filled and calculations on the node commence
INNØDE	One of the inlet node numbers which flows into a common node to be averaged in subroutine TAVG
IRCVAR	A series of flags to denote those nodes which have either a variable capacitance or are tied to a variable capacitor; these are denoted by making IRCVAR of the node equal to the node numbers; Function 12 nodes are the negative of the node number
JOINMX	A counter to indicate the number of pieces of data in Function 11
JTABLE	The table number in which the wc_p versus time for one of the leading nodes for the fluid flow averaging calculations is described
KERR10, KERR11, and KERR12	A flag set to denote an instability in subroutines FLOW or TAVG; the flag is set after detection on one pass through the subroutine and calculations are stopped for detection on a second successive iteration; instability indicates an error in Functions 10, 11, or 12
KFOLOW	The number of the following node as calculated in the consecutive node input section of Function 10
KKTABL	The identification of the table in which the wc_p versus time information is stored for use during the fast fluid flow calculations
KPUNCH	A flag read in on the "TITLE" card; if set to 1, the program punches the temperature-capacitance cards at the completion of the run
KTABLE	The identification of the table in which the wc_p versus time information is stored for use during the fluid flow calculations
KTHMAX	A counter to indicate the number of pieces of data in Function 10

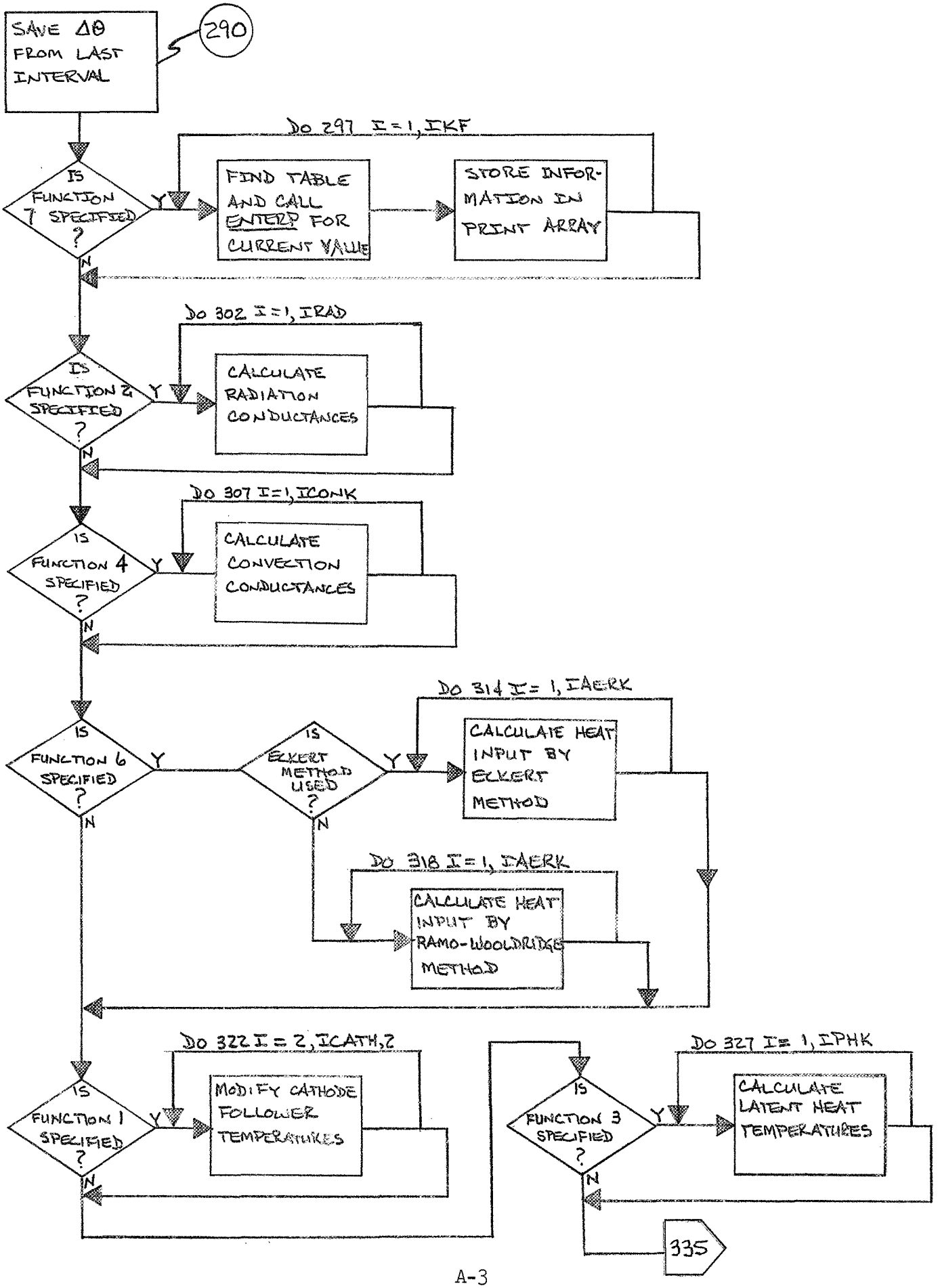
Variable	Description
KTHNEW	The node number of the following node used in the fluid calculations
LASTPR	A counter which indicates the number of printed outputs requested since the last time the print frequency changed
LFOLOW	The number of the following node as calculated in the consecutive node input section of Function 12
LLTABL	The table number where the wc_p versus time information, for the node referred to in the Function 12 input, is stored
LTABLE	The table number where the wc_p versus time information, for the node referred to in the Function 10 input, is stored
MAXNOR	The maximum conductor number used in the problem
MININT	A flag set to 1 if the time interval is less than the minimum specified as problem constant 10 of Function 9
NDEADB	The node number on which the dead-band controller action is based
NEWNOD	The number of the following node in the first card of the consecutive node input section of Functions 10 and 12
NODCLC	A reference area where the number of time intervals since the last temperature calculation, for each of the nodes, is stored
NODVAR	A flag which is set if any capacitors or conductors are variable
NUNODE	The junction node number into which two or more fluid nodes flow in subroutine TAVG
NUTIME	A flag which is set to the number of steady state cycles the problem will handle; when the number is exceeded the time is set past the problem completion time so that calculations stop
POWFAC	The power factor of the subscripted node to indicate the fraction of Q0 from the nuclear heating calculations being generated in that node
PRTIME	The time at which the next printed output will occur
PRUNT2	The storage area containing K-, T-, C-, or Q-, depending on whether the printed output is a conductance, temperature, capacitance, or heat flow
SIGNAL	A logical record tested at various locations in the program to determine if a fatal error has occurred and the run should be aborted

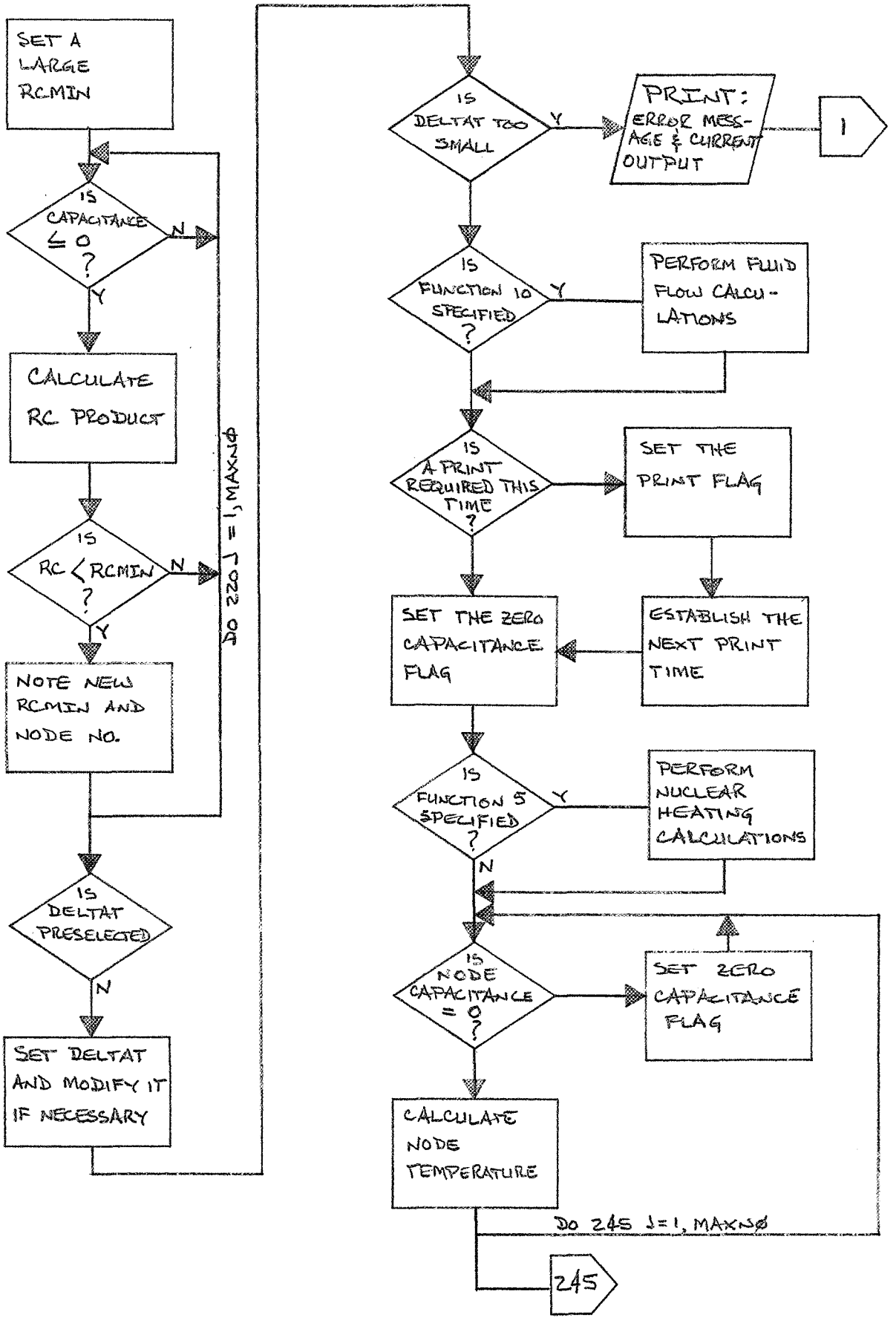
Variable	Description
TDEADB	The temperature upon which the dead-band controller action is based
TIMMAX	The maximum time specified in Constant 2 of the Function 9 input during which the time interval is determined

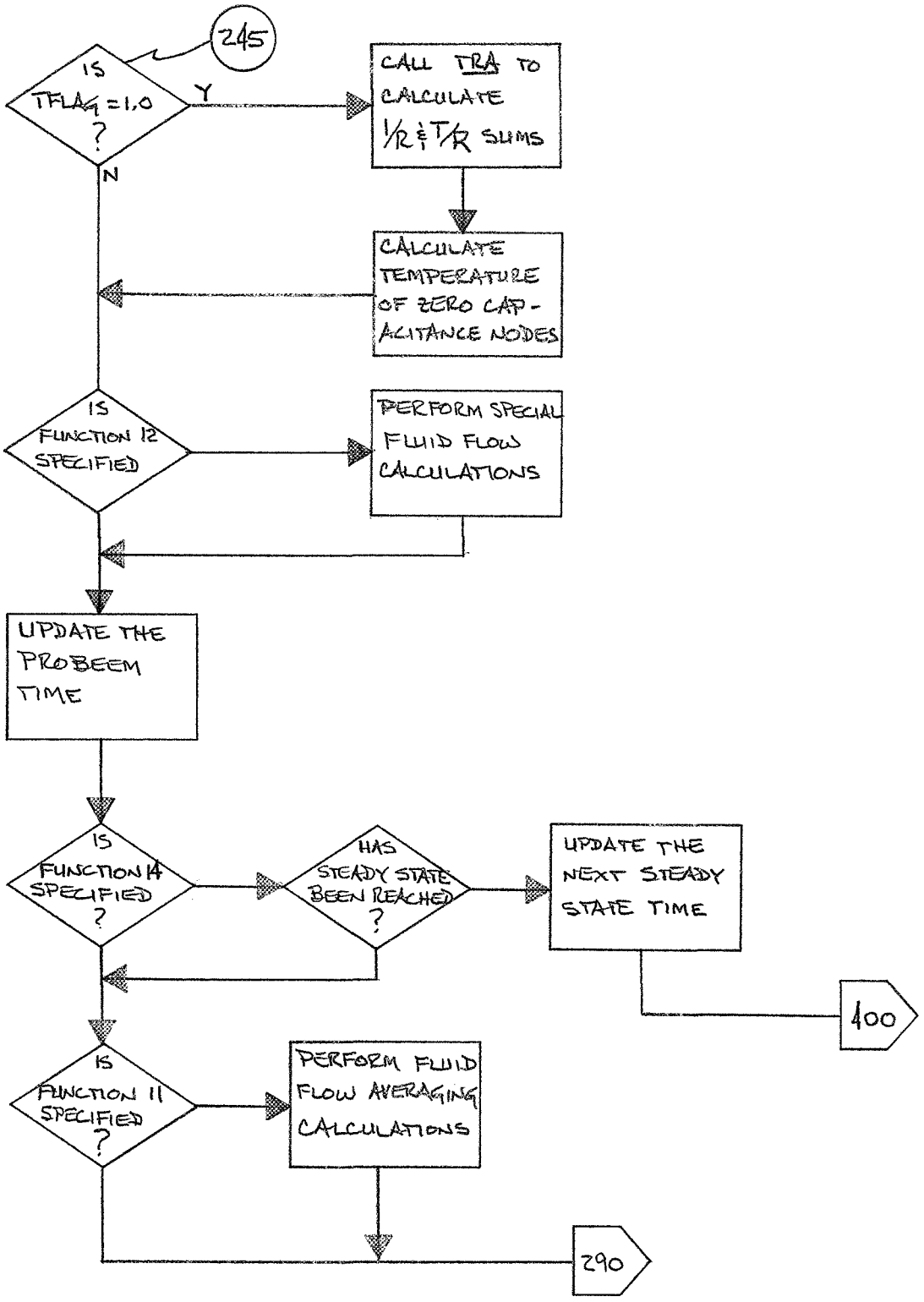
A P P E N D I X A

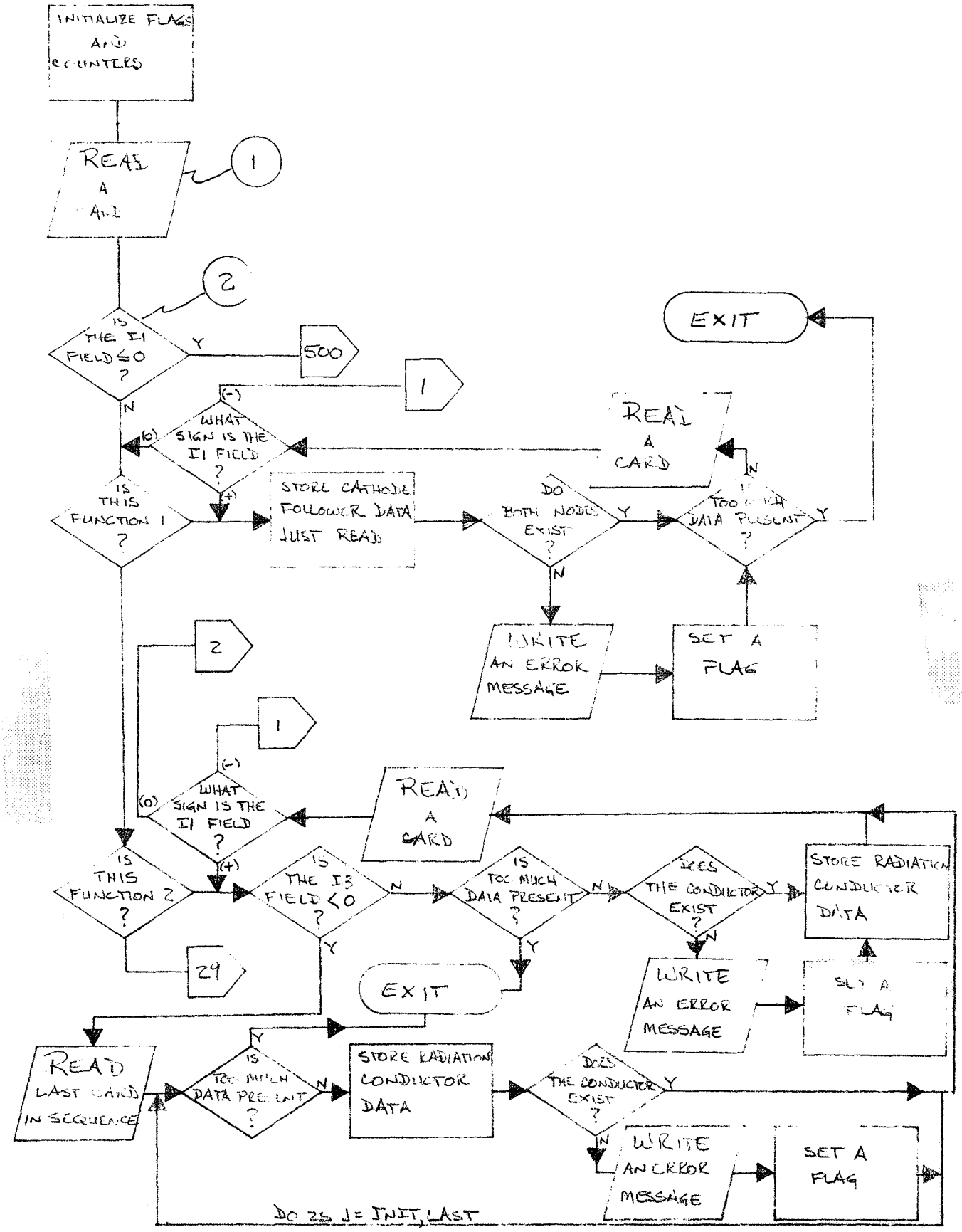
MAIN PROGRAM

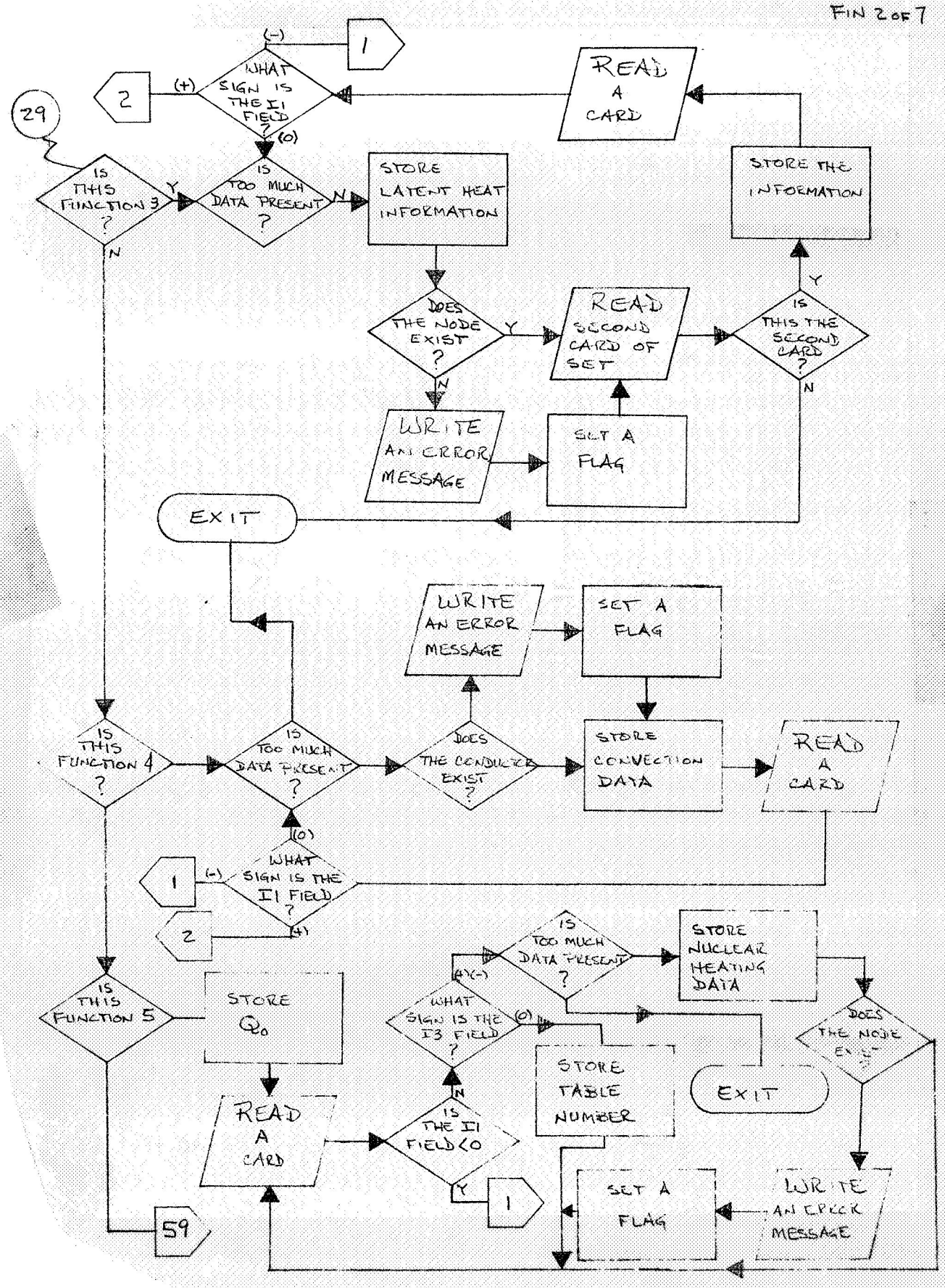


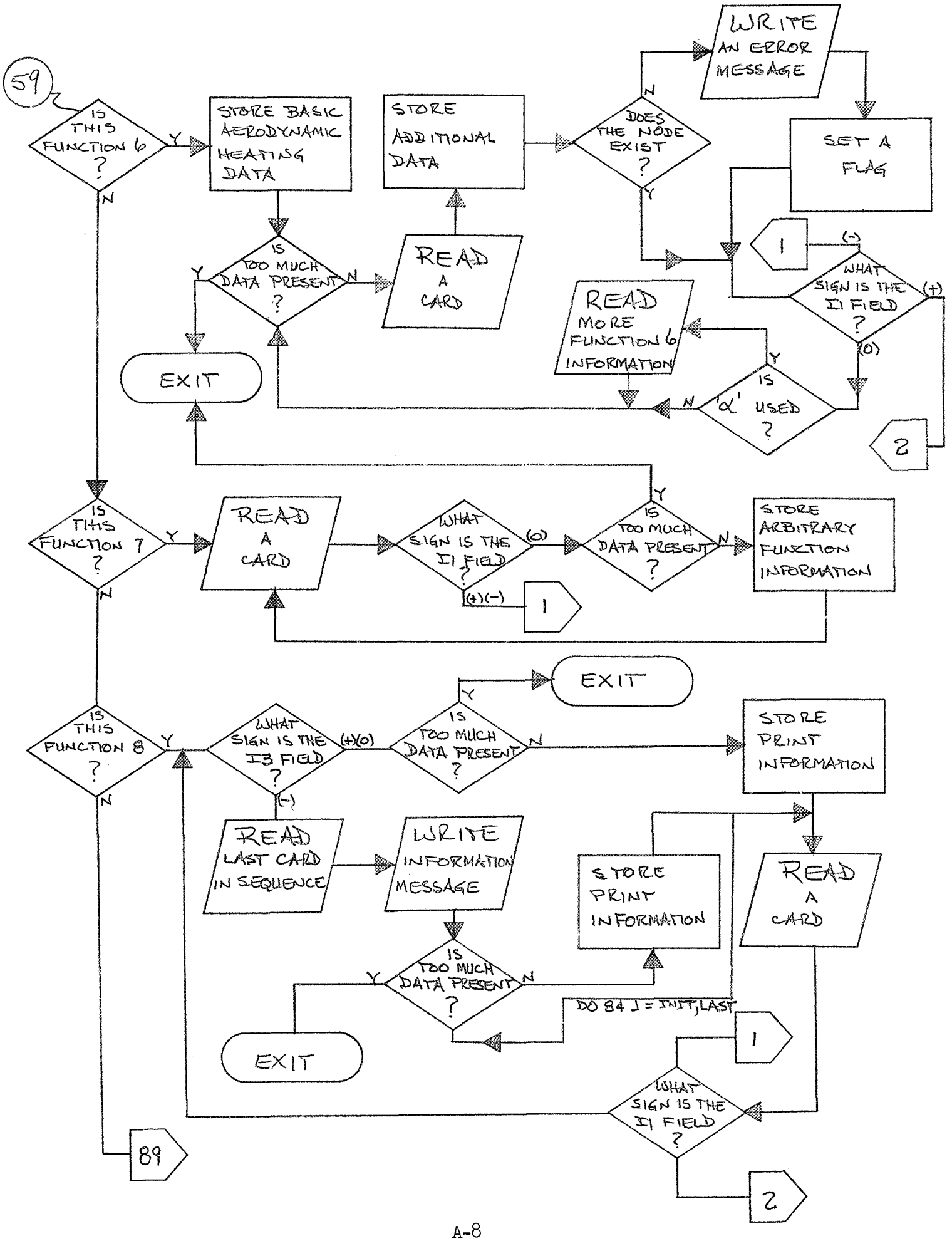

SAVE Δθ FROM LAST INTERVAL
290
DO 297 I = 1, IKF
IS FUNCTION 7 SPECIFIED ?
Y
N
FIND TABLE AND CALL ENTERP FOR CURRENT VALUE
STORE INFORMATION IN PRINT ARRAY
DO 302 I = 1, IRAD
IS FUNCTION 2 SPECIFIED ?
Y
N
CALCULATE RADIATION CONDUCTANCES
DO 307 I = 1, ICONK
IS FUNCTION 4 SPECIFIED ?
Y
N
CALCULATE CONVECTION CONDUCTANCES
DO 314 I = 1, IAERK
IS FUNCTION 6 SPECIFIED ?
Y
N
IS ECKERT METHOD USED ?
Y
N
CALCULATE HEAT INPUT BY ECKERT METHOD
DO 318 I = 1, IAERK
CALCULATE HEAT INPUT BY RAMO-WOOLDRIDGE METHOD
DO 322 I = 2, ICATH, 2
IS FUNCTION 1 SPECIFIED ?
Y
N
MODIFY CATHODE FOLLOWER TEMPERATURES
DO 327 I = 1, IPHK
IS FUNCTION 3 SPECIFIED ?
Y
N
CALCULATE LATENT HEAT TEMPERATURES
335

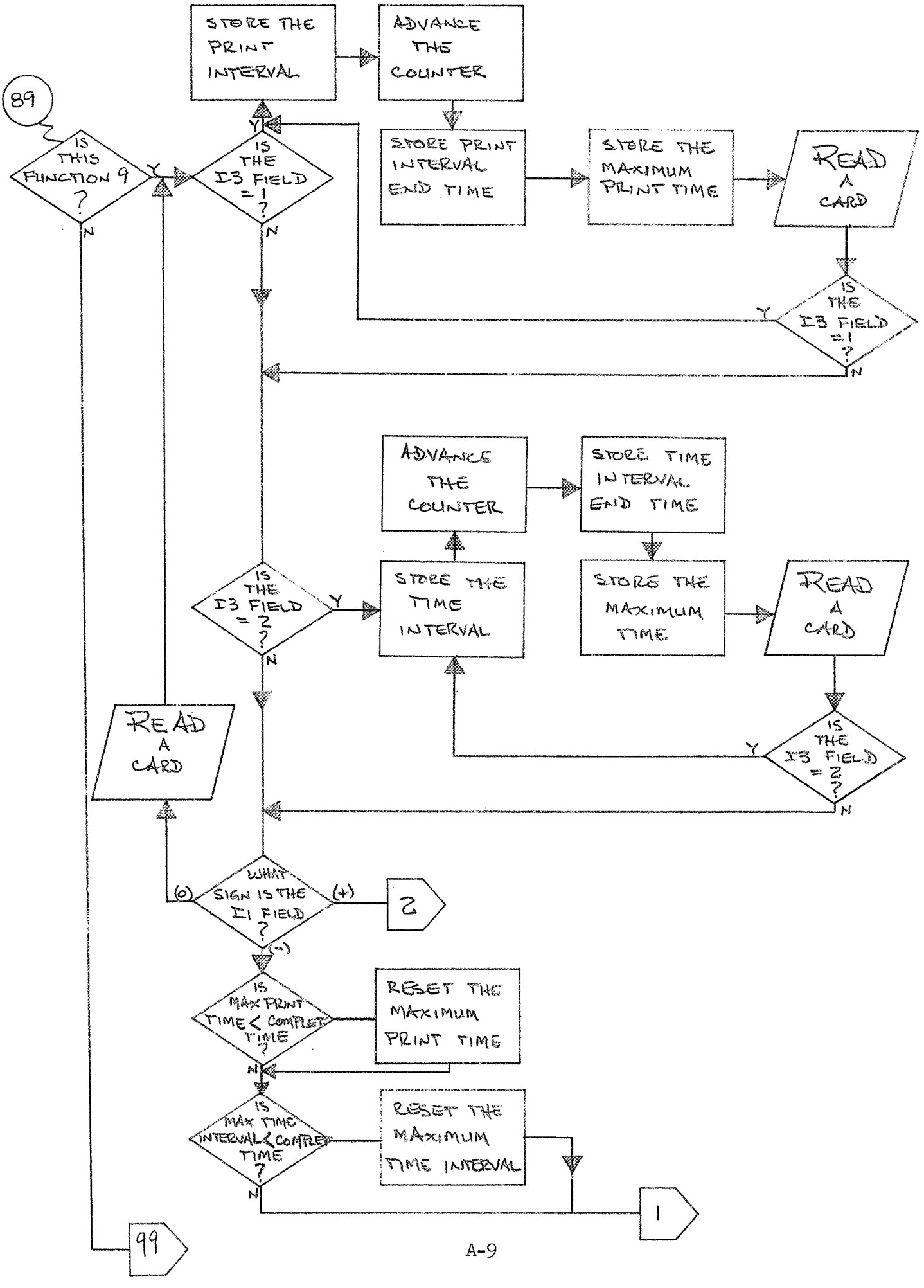

SET A LARGE RCMIN
IS CAPACITANCE ≤ 0 ?
N
Y
CALCULATE RC PRODUCT
IS RC < RCMIN ?
N
Y
NOTE NEW RCMIN AND NODE NO.
DO 220 J = 1, MAXNØ
IS DELTAT PRESELECTED
N
SET DELTAT AND MODIFY IT IF NECESSARY
IS DELTAT TOO SMALL
Y
PRINT: ERROR MESSAGE & CURRENT OUTPUT
1
IS FUNCTION 10 SPECIFIED ?
Y
PERFORM FLUID FLOW CALCULATIONS
IS A PRINT REQUIRED THIS TIME ?
SET THE PRINT FLAG
ESTABLISH THE NEXT PRINT TIME
SET THE ZERO CAPACITANCE FLAG
IS FUNCTION 5 SPECIFIED ?
Y
PERFORM NUCLEAR HEATING CALCULATIONS
N
IS NODE CAPACITANCE = 0 ?
SET ZERO CAPACITANCE FLAG
CALCULATE NODE TEMPERATURE
DO 245 J = 1, MAXNØ
245

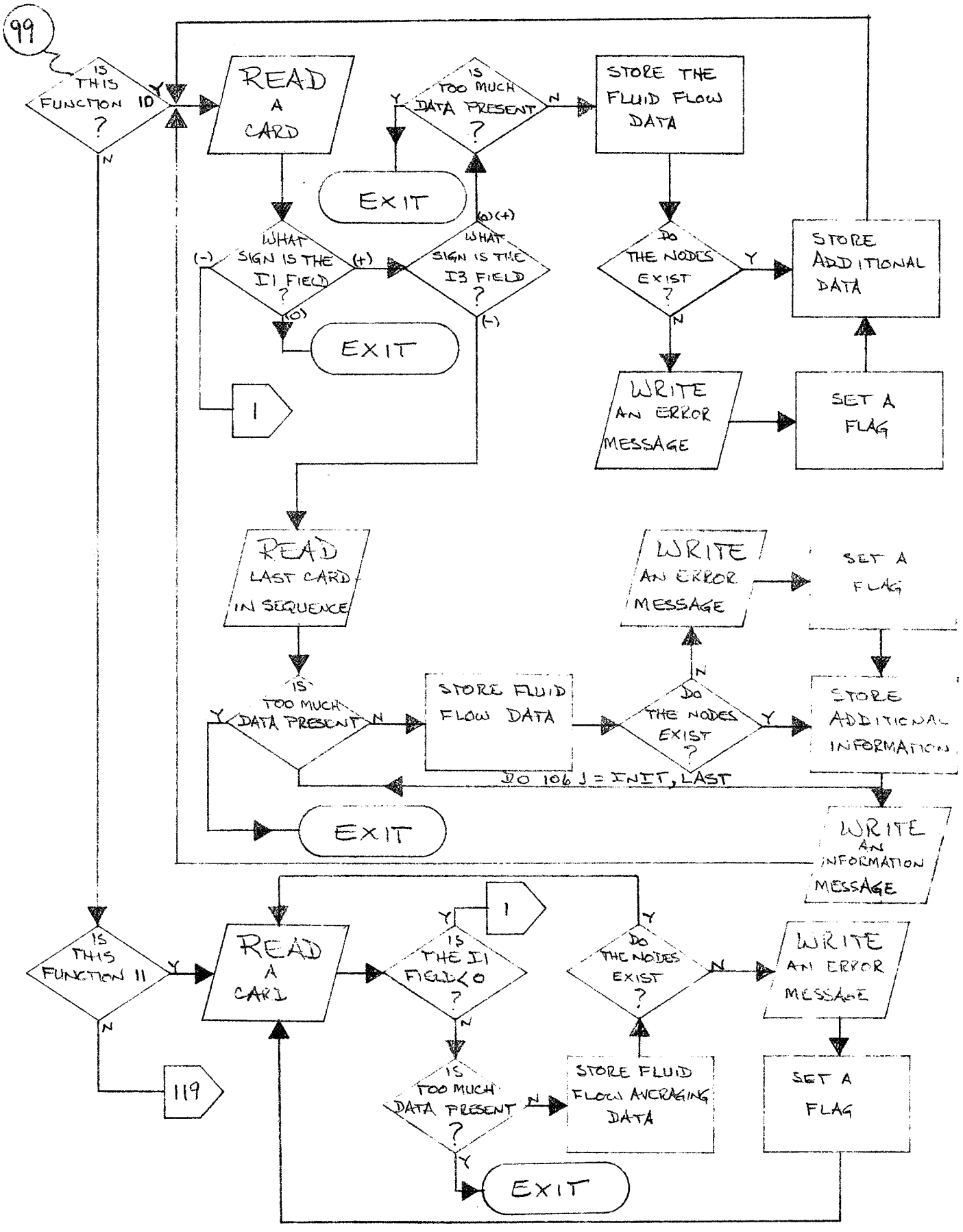

245
IS TFLAG = 1.0 ?
Y
N
CALL TRA TO CALCULATE 1/R & T/R SUMS
CALCULATE TEMPERATURE OF ZERO CAPACITANCE NODES
IS FUNCTION 12 SPECIFIED
PERFORM SPECIAL FLUID FLOW CALCULATIONS
UPDATE THE PROBEEM TIME
IS FUNCTION 14 SPECIFIED ?
HAS STEADY STATE BEEN REACHED ?
UPDATE THE NEXT STEADY STATE TIME
400
IS FUNCTION 11 SPECIFIED ?
PERFORM FLUID FLOW AVERAGING CALCULATIONS
290

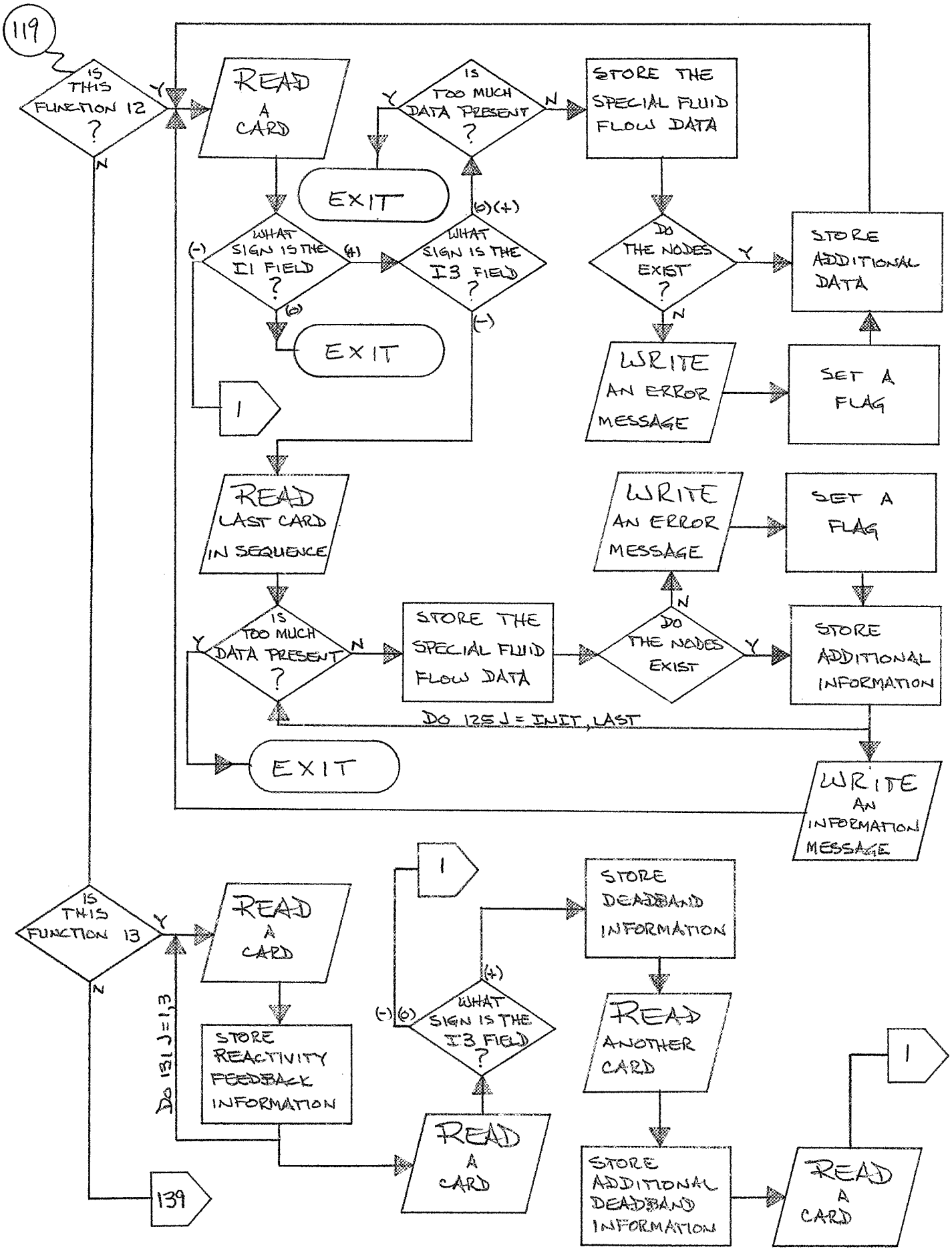

INITIALIZE FLAGS AND COUNTERS
READ A CARD
1
2
IS THE I1 FIELD ≤ 0 ?
Y
500
N
EXIT
1
(-)
(0)
WHAT SIGN IS THE I1 FIELD ?
(+)
READ A CARD
IS THIS FUNCTION 1 ?
STORE CATHODE FOLLOWER DATA JUST READ
DO BOTH NODES EXIST ?
Y
TOO MUCH DATA PRESENT ?
Y
N
N
WRITE AN ERROR MESSAGE
SET A FLAG
2
1
(-)
(0)
WHAT SIGN IS THE I1 FIELD ?
READ A CARD
(+)
IS THIS FUNCTION 2 ?
IS THE I3 FIELD < 0 ?
N
IS TOO MUCH DATA PRESENT ?
N
DOES THE CONDUCTOR EXIST ?
Y
STORE RADIATION CONDUCTOR DATA
N
Y
29
EXIT
WRITE AN ERROR MESSAGE
SET A FLAG
READ LAST CARD IN SEQUENCE
Y
IS TOO MUCH DATA PRESENT ?
N
STORE RADIATION CONDUCTOR DATA
DOES THE CONDUCTOR EXIST ?
Y
N
WRITE AN ERROR MESSAGE
SET A FLAG
DO 25 J = INIT, LAST

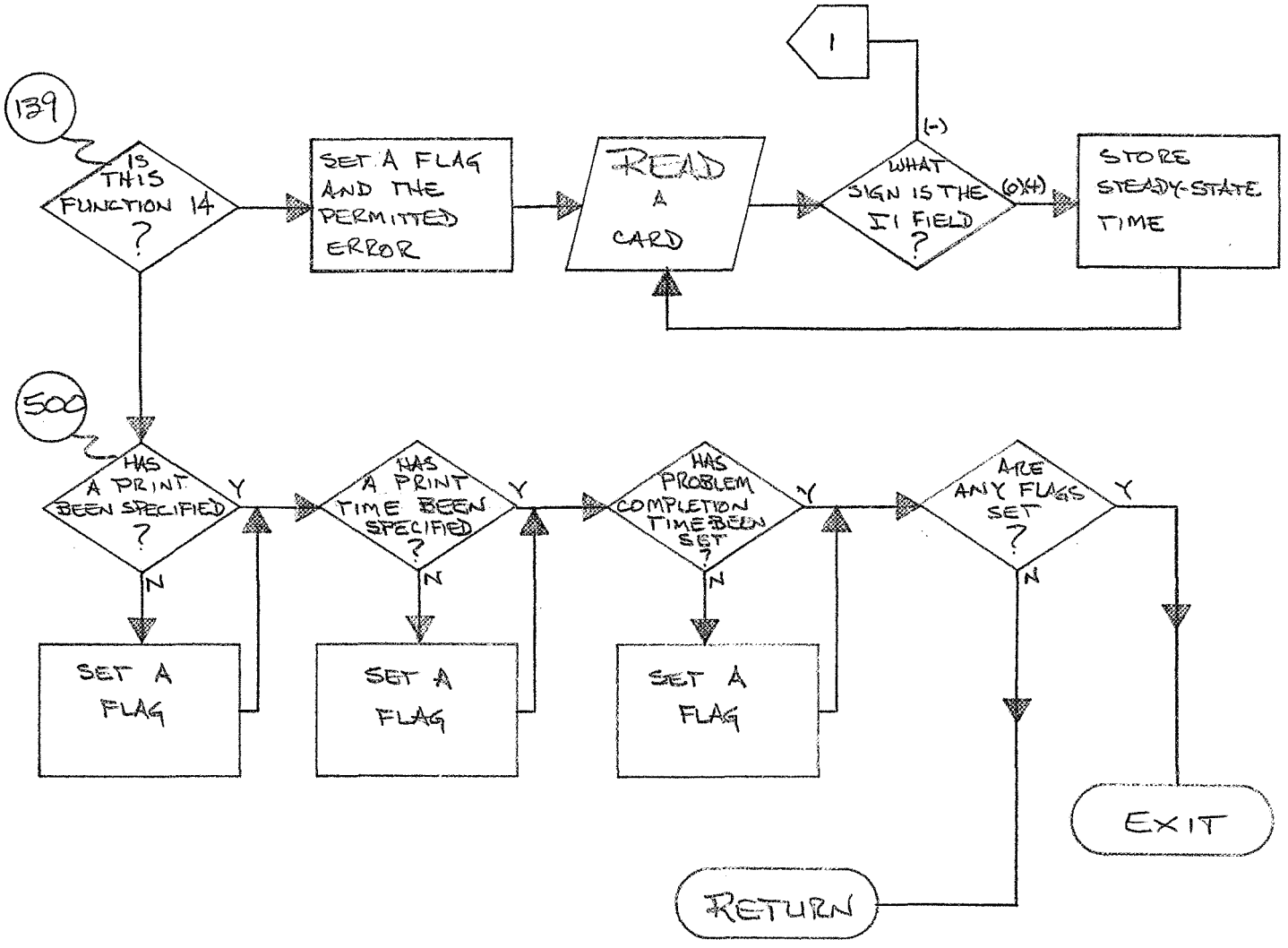

29
IS THIS FUNCTION 3 ?
Y
N
IS TOO MUCH DATA PRESENT ?
N
STORE LATENT HEAT INFORMATION
DOES THE NODE EXIST ?
Y
N
READ SECOND CARD OF SET
IS THIS THE SECOND CARD ?
Y
N
STORE THE INFORMATION
WRITE AN ERROR MESSAGE
SET A FLAG
EXIT
READ A CARD
WHAT SIGN IS THE I1 FIELD ?
(-)
(+)
(0)
1
2
IS THIS FUNCTION 4 ?
IS TOO MUCH DATA PRESENT ?
DOES THE CONDUCTOR EXIST ?
WRITE AN ERROR MESSAGE
SET A FLAG
STORE CONVECTION DATA
READ A CARD
WHAT SIGN IS THE I1 FIELD ?
1
2
IS THIS FUNCTION 5
STORE Q_0
READ A CARD
IS THE I1 FIELD < 0
N
Y
WHAT SIGN IS THE I3 FIELD ?
IS TOO MUCH DATA PRESENT ?
STORE NUCLEAR HEATING DATA
STORE TABLE NUMBER
DOES THE NODE EXIST ?
EXIT
SET A FLAG
WRITE AN ERROR MESSAGE
59

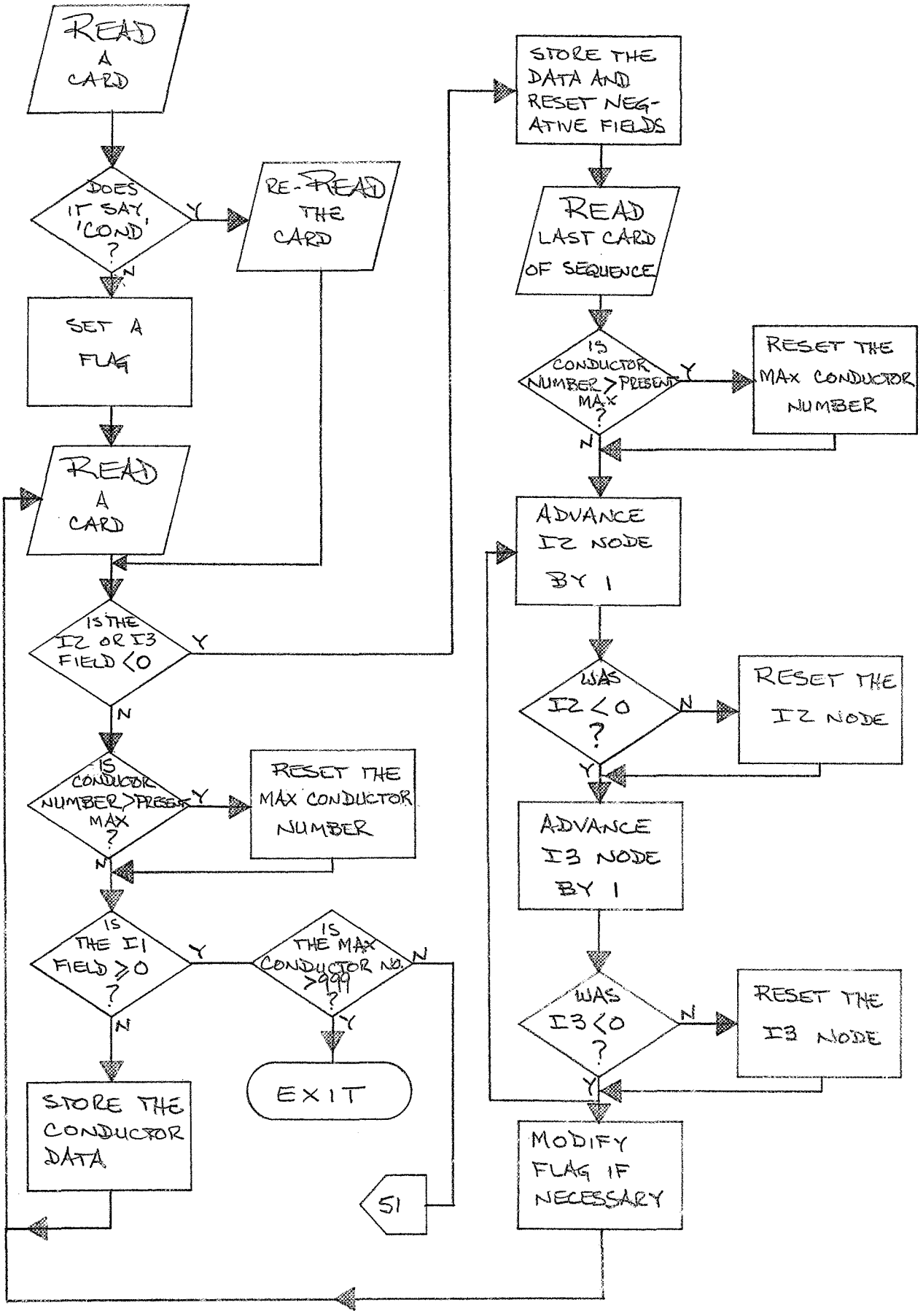

59
IS THIS FUNCTION 6 ?
Y
N
STORE BASIC AERODYNAMIC HEATING DATA
STORE ADDITIONAL DATA
DOES THE NODE EXIST ?
N
Y
WRITE AN ERROR MESSAGE
SET A FLAG
IS TOO MUCH DATA PRESENT ?
Y
N
READ A CARD
EXIT
1
(-)
WHAT SIGN IS THE I1 FIELD ?
(+)
(0)
READ MORE FUNCTION 6 INFORMATION
IS 'α' USED ?
Y
N
2
IS THIS FUNCTION 7 ?
Y
N
READ A CARD
WHAT SIGN IS THE I1 FIELD ?
(0)
(+)(-)
1
IS TOO MUCH DATA PRESENT ?
Y
N
STORE ARBITRARY FUNCTION INFORMATION
EXIT
IS THIS FUNCTION 8 ?
Y
N
WHAT SIGN IS THE I3 FIELD ?
(+)(0)
(-)
IS TOO MUCH DATA PRESENT ?
Y
N
STORE PRINT INFORMATION
READ LAST CARD IN SEQUENCE
WRITE INFORMATION MESSAGE
IS TOO MUCH DATA PRESENT ?
Y
N
STORE PRINT INFORMATION
READ A CARD
EXIT
DO 84 J = INIT,LAST
1
WHAT SIGN IS THE I1 FIELD ?
2
89

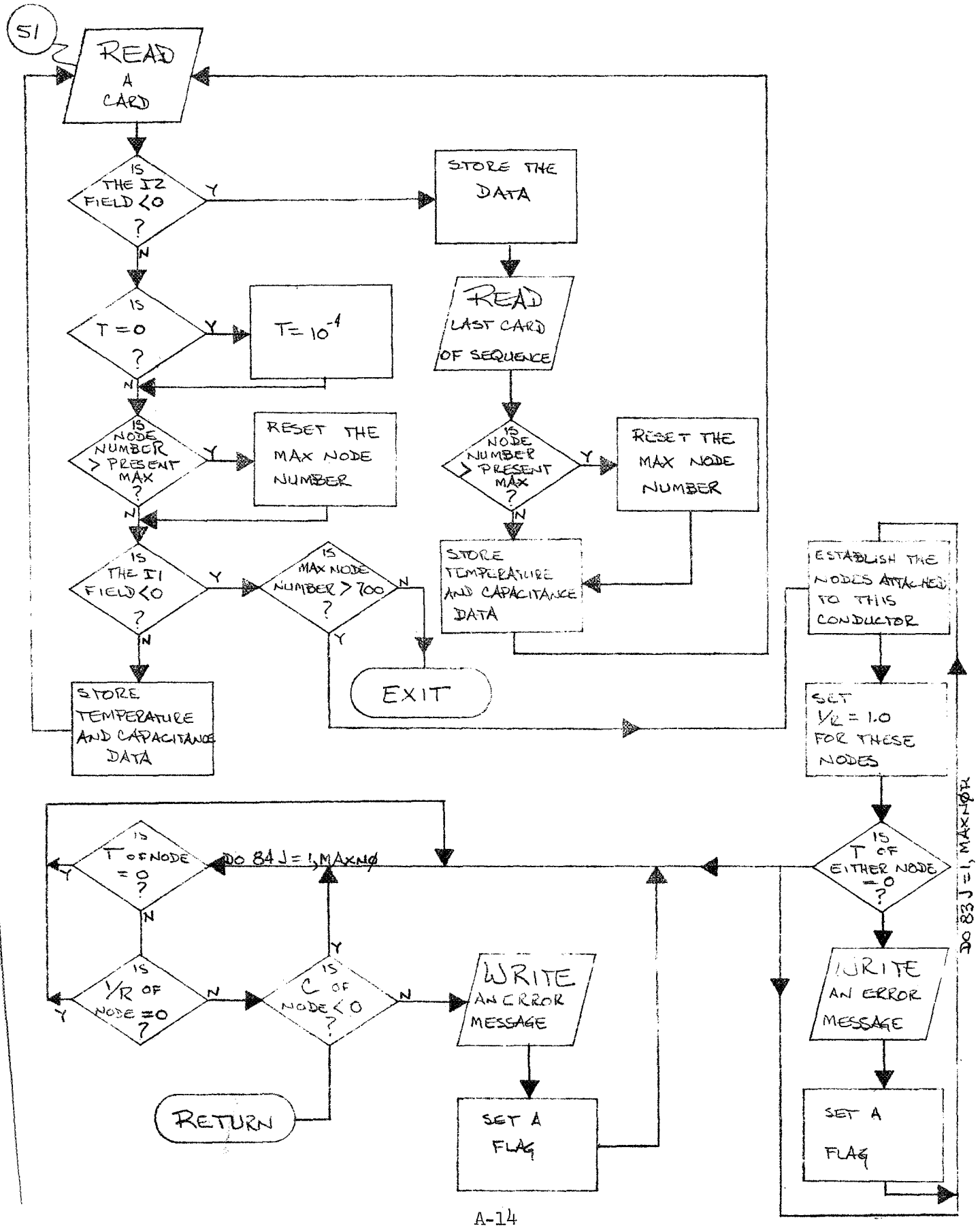

89
IS THIS FUNCTION 9 ?
Y
N
IS THE I3 FIELD = 1 ?
Y
N
STORE THE PRINT INTERVAL
ADVANCE THE COUNTER
STORE PRINT INTERVAL END TIME
STORE THE MAXIMUM PRINT TIME
READ A CARD
IS THE I3 FIELD = 1 ?
Y
N
ADVANCE THE COUNTER
STORE TIME INTERVAL END TIME
IS THE I3 FIELD = 2 ?
Y
N
STORE THE TIME INTERVAL
STORE THE MAXIMUM TIME
READ A CARD
IS THE I3 FIELD = 2 ?
Y
N
READ A CARD
WHAT SIGN IS THE I1 FIELD ?
(0)
(+)
(-)
2
IS MAX PRINT TIME < COMPLET TIME ?
N
RESET THE MAXIMUM PRINT TIME
IS MAX TIME INTERVAL < COMPLET TIME ?
N
RESET THE MAXIMUM TIME INTERVAL
1
99


99
IS THIS FUNCTION 10 ?
Y
N
READ A CARD
IS TOO MUCH DATA PRESENT ?
Y
N
EXIT
STORE THE FLUID FLOW DATA
WHAT SIGN IS THE I1 FIELD ?
(-)
(+)
(0)
WHAT SIGN IS THE I3 FIELD ?
(0)(+)
(-)
EXIT
1
DO THE NODES EXIST ?
Y
N
STORE ADDITIONAL DATA
WRITE AN ERROR MESSAGE
SET A FLAG
READ LAST CARD IN SEQUENCE
IS TOO MUCH DATA PRESENT
Y
N
STORE FLUID FLOW DATA
DO THE NODES EXIST ?
N
Y
WRITE AN ERROR MESSAGE
SET A FLAG
STORE ADDITIONAL INFORMATION
DO 106 J = INIT, LAST
EXIT
WRITE AN INFORMATION MESSAGE
IS THIS FUNCTION 11 ?
Y
N
119
READ A CARD
IS THE I1 FIELD < 0 ?
Y
N
1
IS TOO MUCH DATA PRESENT ?
Y
N
EXIT
DO THE NODES EXIST ?
Y
N
STORE FLUID FLOW AVERAGING DATA
WRITE AN ERROR MESSAGE
SET A FLAG

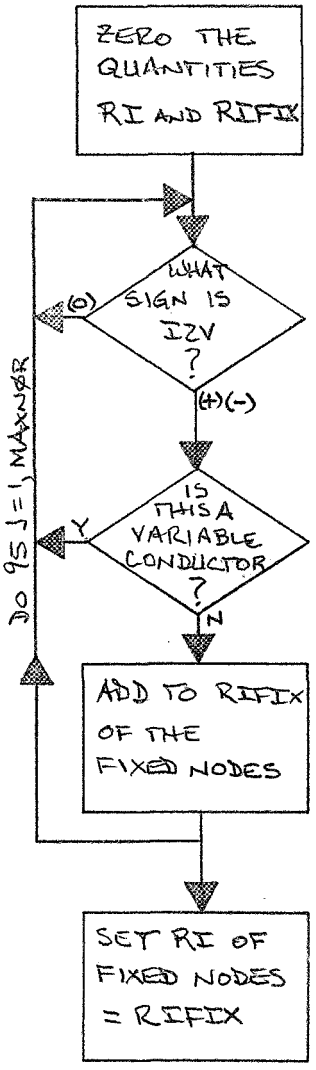

119
IS THIS FUNCTION 12 ?
Y
N
READ A CARD
IS TOO MUCH DATA PRESENT ?
Y
N
EXIT
STORE THE SPECIAL FLUID FLOW DATA
WHAT SIGN IS THE I1 FIELD ?
(-)
(+)
(0)
WHAT SIGN IS THE I3 FIELD ?
(0)(+)
(-)
EXIT
DO THE NODES EXIST ?
Y
N
STORE ADDITIONAL DATA
WRITE AN ERROR MESSAGE
SET A FLAG
1
READ LAST CARD IN SEQUENCE
IS TOO MUCH DATA PRESENT ?
Y
N
STORE THE SPECIAL FLUID FLOW DATA
DO THE NODES EXIST
N
Y
WRITE AN ERROR MESSAGE
SET A FLAG
STORE ADDITIONAL INFORMATION
DO 125 J = INIT, LAST
EXIT
WRITE AN INFORMATION MESSAGE
IS THIS FUNCTION 13
Y
N
READ A CARD
DO 131 J = 1,3
STORE REACTIVITY FEEDBACK INFORMATION
1
WHAT SIGN IS THE I3 FIELD ?
(+)
(-)(0)
READ A CARD
STORE DEADBAND INFORMATION
READ ANOTHER CARD
STORE ADDITIONAL DEADBAND INFORMATION
1
READ A CARD
139


1
139
IS THIS FUNCTION 14 ?
SET A FLAG AND THE PERMITTED ERROR
READ A CARD
WHAT SIGN IS THE I1 FIELD ?
(-)
(0)(+)
STORE STEADY-STATE TIME
500
HAS A PRINT BEEN SPECIFIED ?
HAS A PRINT TIME BEEN SPECIFIED ?
HAS PROBLEM COMPLETION TIME BEEN SET ?
ARE ANY FLAGS SET ?
Y
N
SET A FLAG
SET A FLAG
SET A FLAG
EXIT
RETURN

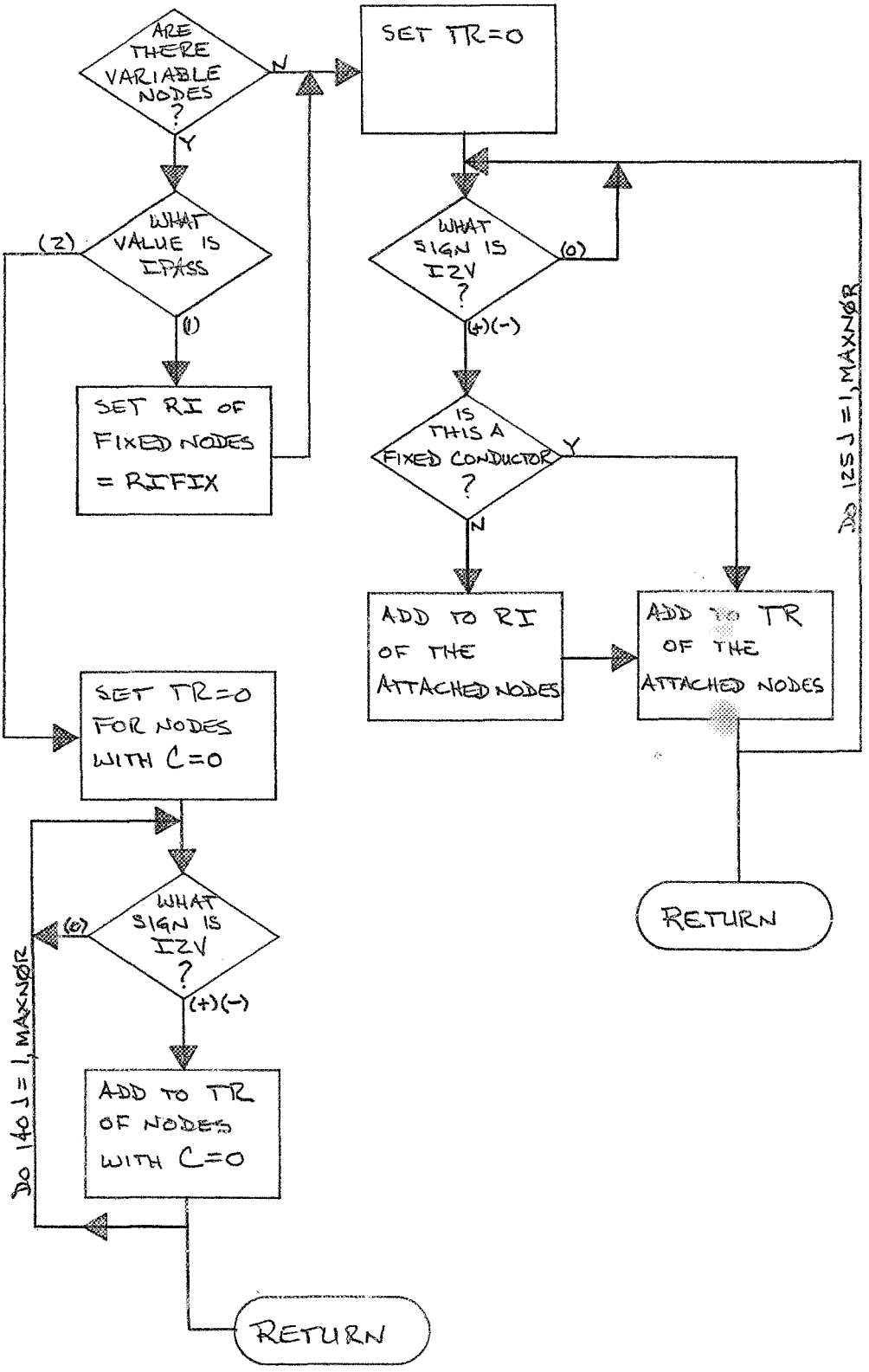

READ A CARD
DOES IT SAY 'COND' ?
Y
RE-READ THE CARD
N
SET A FLAG
READ A CARD
IS THE I2 OR I3 FIELD <0
Y
N
IS CONDUCTOR NUMBER > PRESENT MAX ?
Y
RESET THE MAX CONDUCTOR NUMBER
N
IS THE I1 FIELD ≥0 ?
Y
N
IS THE MAX CONDUCTOR NO. >999 ?
N
Y
EXIT
STORE THE CONDUCTOR DATA
51
STORE THE DATA AND RESET NEGATIVE FIELDS
READ LAST CARD OF SEQUENCE
IS CONDUCTOR NUMBER > PRESENT MAX ?
Y
RESET THE MAX CONDUCTOR NUMBER
N
ADVANCE I2 NODE BY 1
WAS I2 <0 ?
N
RESET THE I2 NODE
Y
ADVANCE I3 NODE BY 1
WAS I3 <0 ?
N
RESET THE I3 NODE
Y
MODIFY FLAG IF NECESSARY

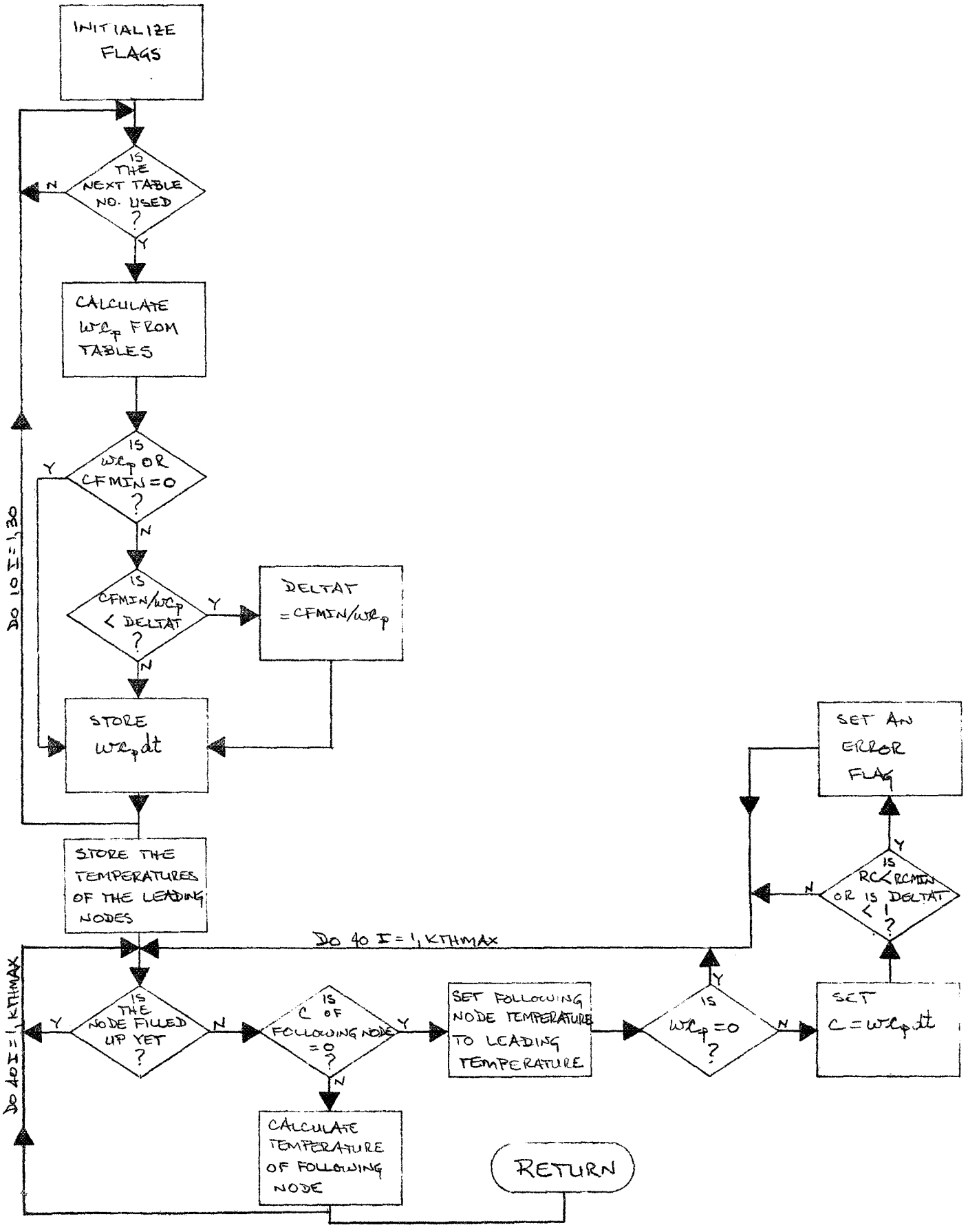

51
READ A CARD
IS THE IZ FIELD < 0 ?
Y
N
STORE THE DATA
READ LAST CARD OF SEQUENCE
IS T = 0 ?
Y
T = 10^-4
N
IS NODE NUMBER > PRESENT MAX ?
Y
RESET THE MAX NODE NUMBER
N
IS NODE NUMBER > PRESENT MAX ?
Y
RESET THE MAX NODE NUMBER
N
IS THE I1 FIELD < 0 ?
Y
IS MAX NODE NUMBER > 700 ?
N
Y
EXIT
N
STORE TEMPERATURE AND CAPACITANCE DATA
STORE TEMPERATURE AND CAPACITANCE DATA
ESTABLISH THE NODES ATTACHED TO THIS CONDUCTOR
SET 1/R = 1.0 FOR THESE NODES
DO 83 J = 1, MAXNØR
IS T OF EITHER NODE = 0 ?
Y
N
DO 84 J = 1, MAXNØ
IS T OF NODE = 0 ?
Y
N
IS 1/R OF NODE = 0 ?
Y
N
IS C OF NODE < 0 ?
Y
N
WRITE AN ERROR MESSAGE
WRITE AN ERROR MESSAGE
SET A FLAG
SET A FLAG
RETURN

ENTRY RFIX

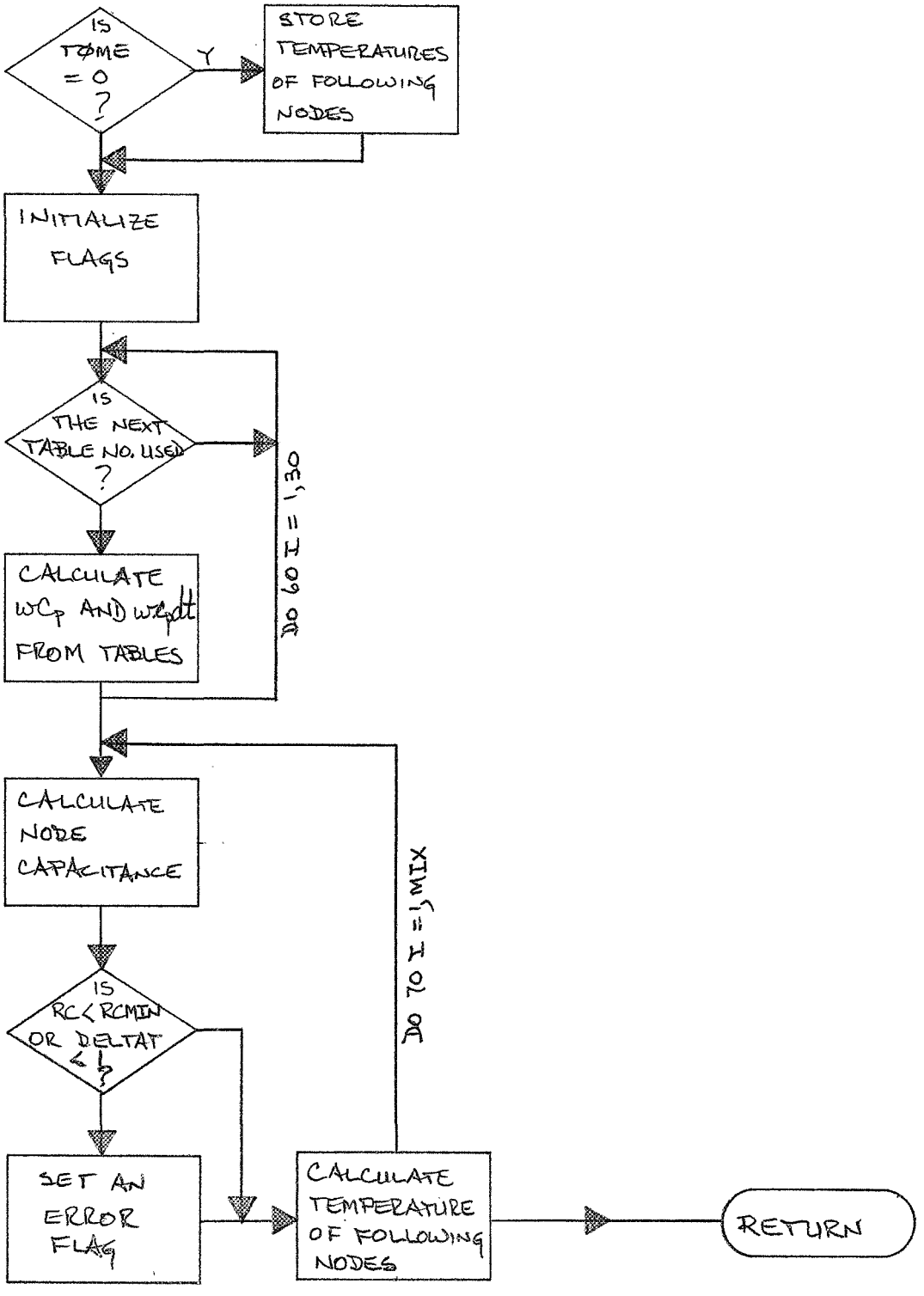


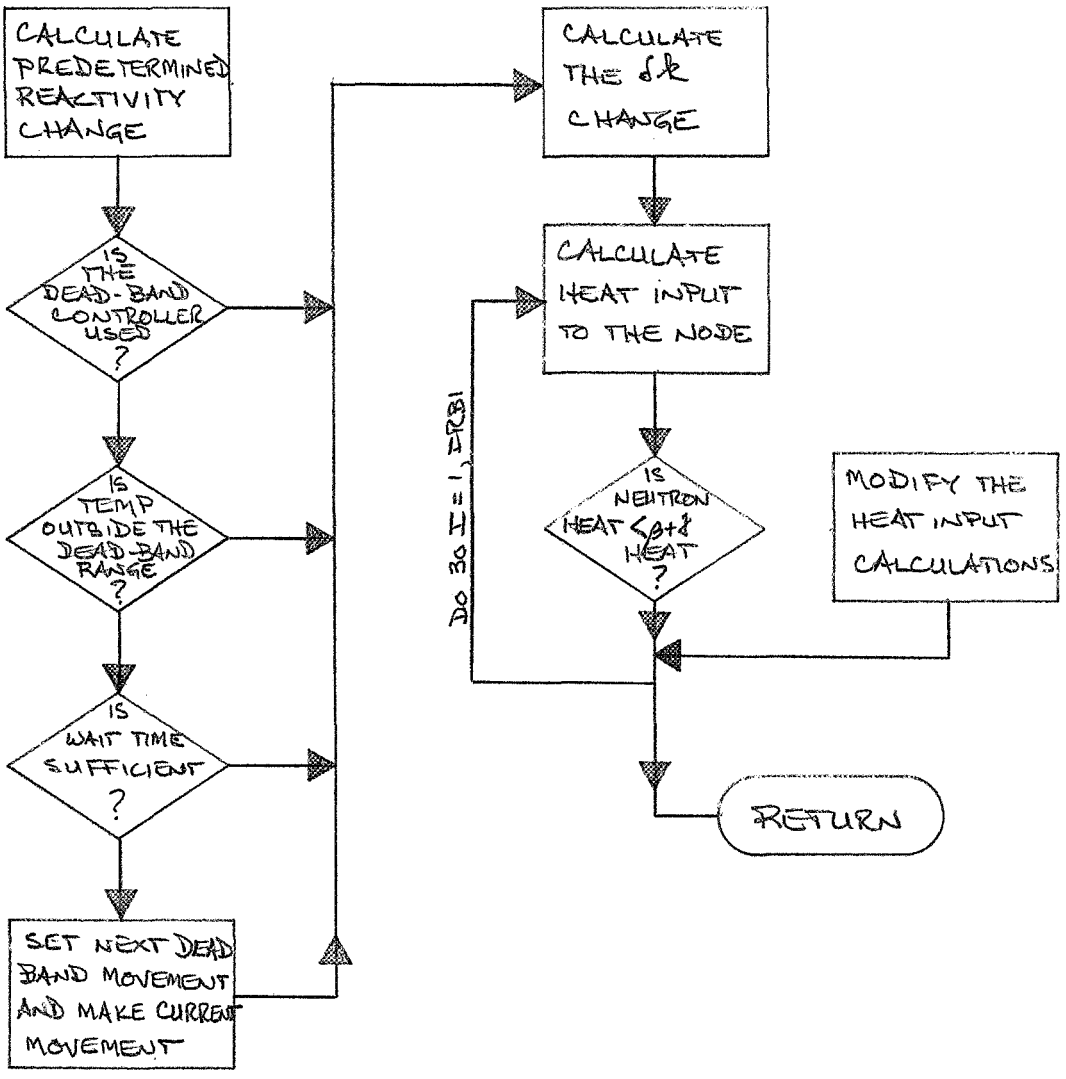
ENTRY TRA

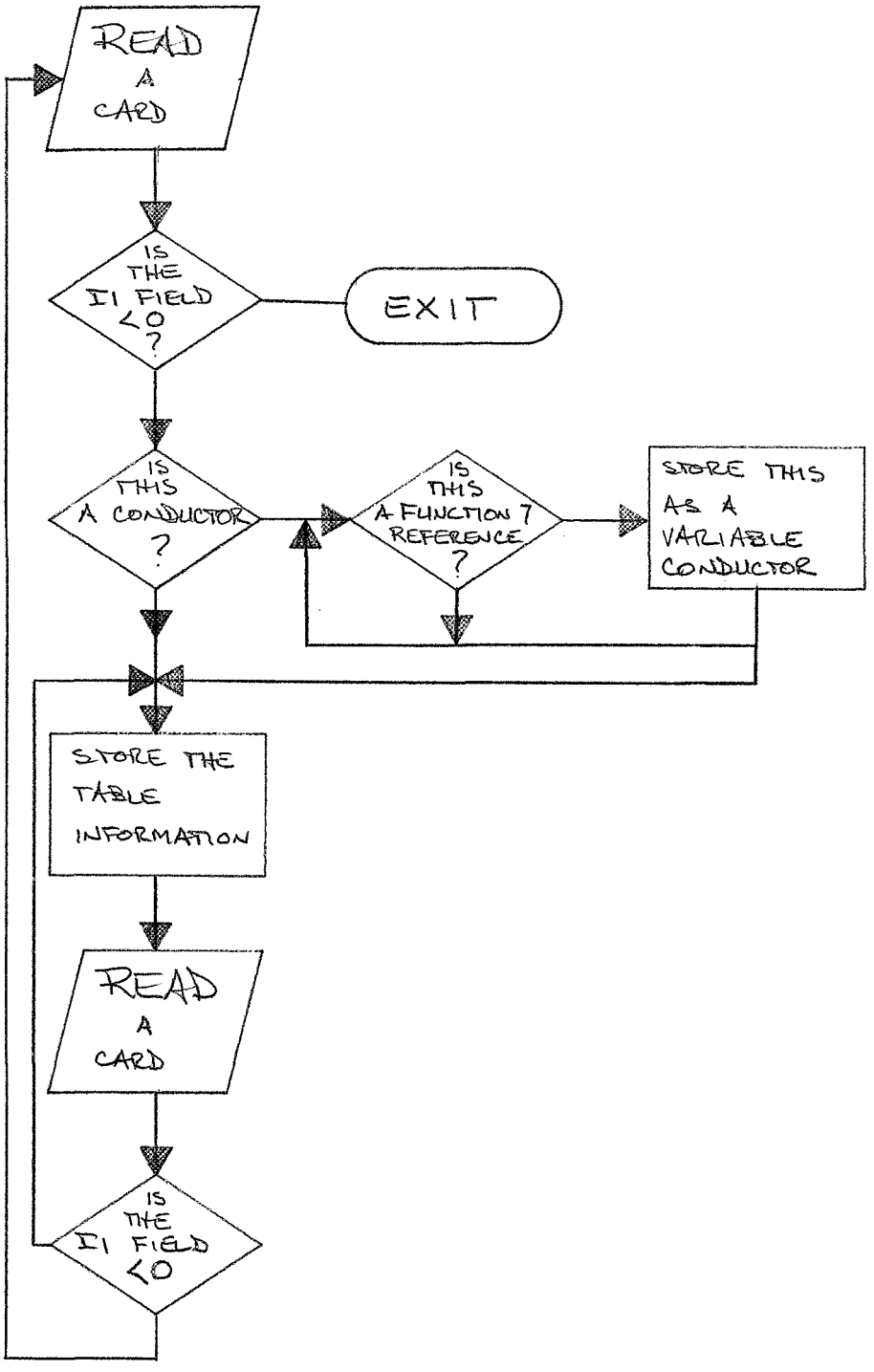


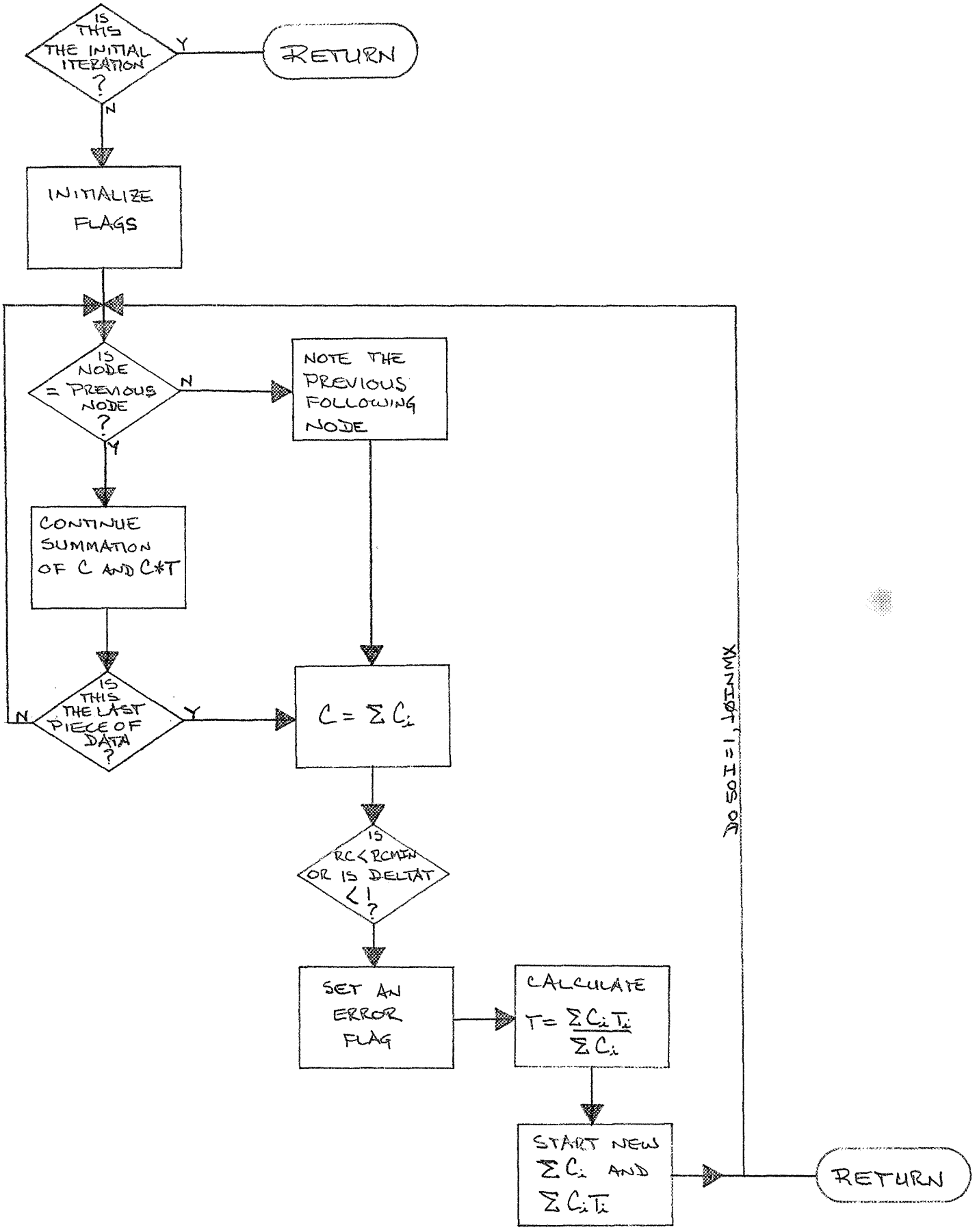

INITIALIZE FLAGS
IS THE NEXT TABLE NO. USED ?
N
Y
CALCULATE WC_p FROM TABLES
IS WC_p OR CFMIN = 0 ?
Y
N
DO 10 I = 1, 30
IS CFMIN/WC_p < DELTAT ?
Y
DELTAT = CFMIN/WC_p
N
STORE $WC_p dt$
STORE THE TEMPERATURES OF THE LEADING NODES
DO 40 I = 1, KTHMAX
DO 40 I = 1, KTHMAX
IS THE NODE FILLED UP YET ?
Y
N
IS C OF FOLLOWING NODE = 0 ?
Y
N
SET FOLLOWING NODE TEMPERATURE TO LEADING TEMPERATURE
IS WC_p = 0 ?
Y
N
SET C = $WC_p dt$
IS RC < RCMIN OR IS DELTAT < 1 ?
Y
N
SET AN ERROR FLAG
CALCULATE TEMPERATURE OF FOLLOWING NODE
RETURN

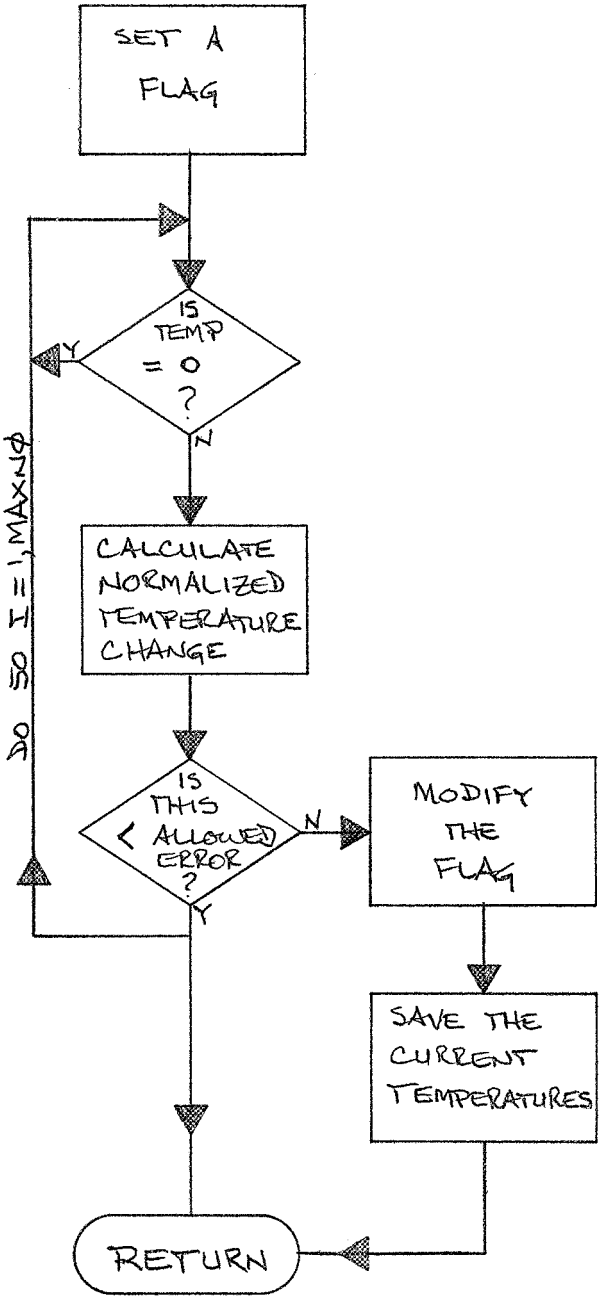
ENTRY FSTFLØ

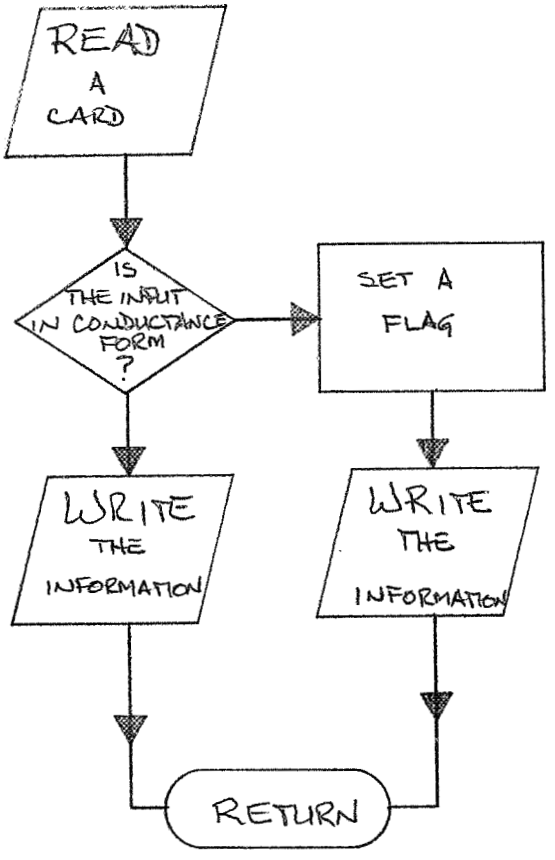



CALCULATE PREDETERMINED REACTIVITY CHANGE
IS THE DEAD-BAND CONTROLLER USED ?
IS TEMP OUTSIDE THE DEAD-BAND RANGE ?
IS WAIT TIME SUFFICIENT ?
SET NEXT DEAD BAND MOVEMENT AND MAKE CURRENT MOVEMENT
CALCULATE THE δk CHANGE
CALCULATE HEAT INPUT TO THE NODE
IS NEUTRON HEAT <β+δ HEAT ?
DO 30 H = 1, NRBI
MODIFY THE HEAT INPUT CALCULATIONS
RETURN

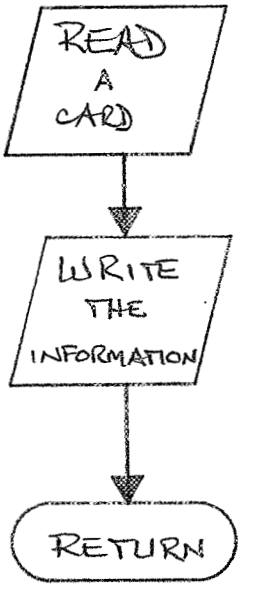

READ A CARD
IS THE I1 FIELD <0 ?
EXIT
IS THIS A CONDUCTOR ?
IS THIS A FUNCTION 7 REFERENCE ?
STORE THIS AS A VARIABLE CONDUCTOR
STORE THE TABLE INFORMATION
READ A CARD
IS THE I1 FIELD <0

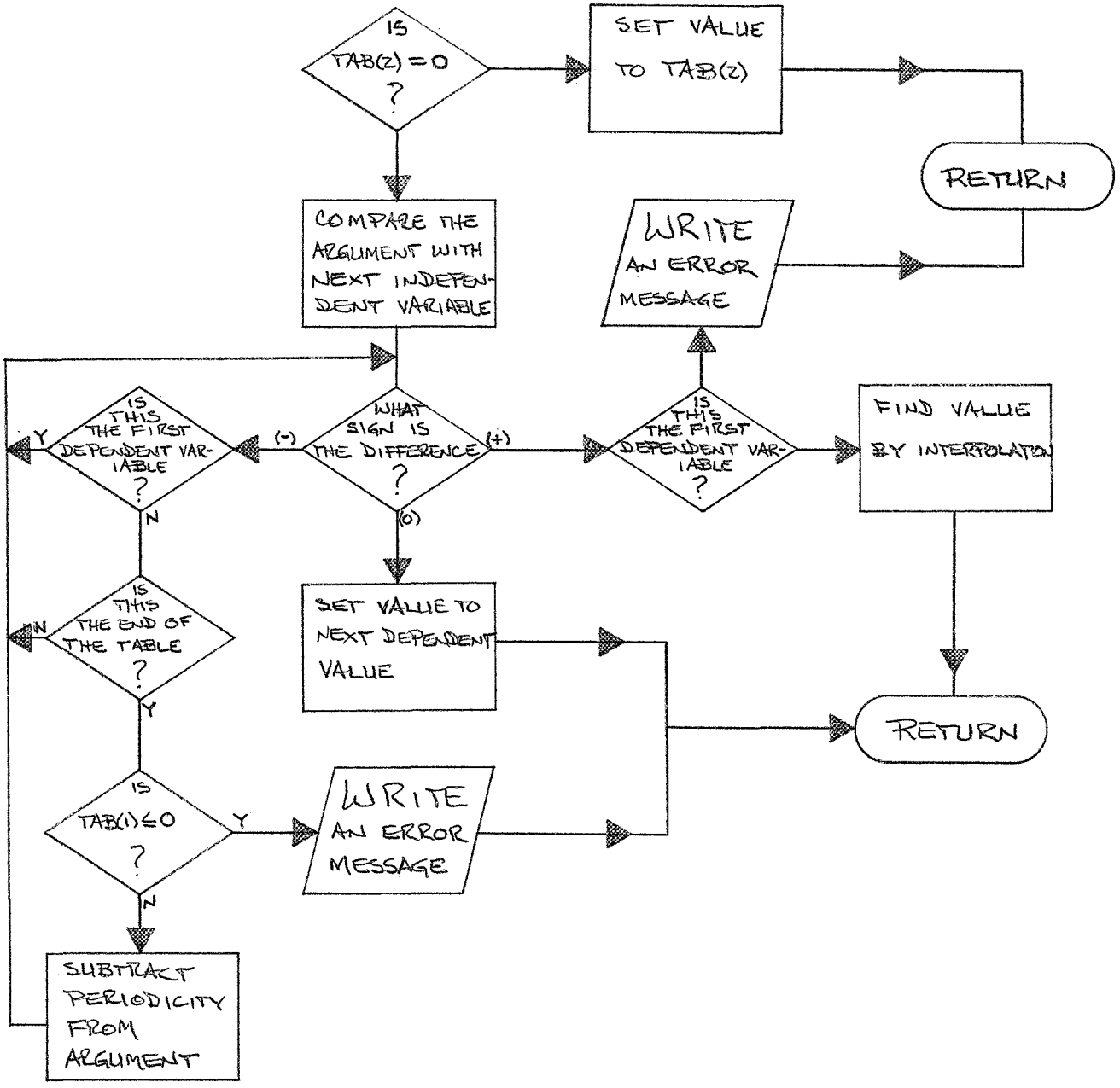

IS THIS THE INITIAL ITERATION ?
Y
RETURN
N
INITIALIZE FLAGS
IS NODE = PREVIOUS NODE ?
N
NOTE THE PREVIOUS FOLLOWING NODE
Y
CONTINUE SUMMATION OF C AND C*T
IS THIS THE LAST PIECE OF DATA ?
N
Y
C = Σ Cᵢ
IS RC < RCMIN OR IS DELTAT < 1 ?
SET AN ERROR FLAG
CALCULATE T = Σ Cᵢ Tᵢ / Σ Cᵢ
START NEW Σ Cᵢ AND Σ Cᵢ Tᵢ
DO 50 I = 1, NUMIOT
RETURN


SET A FLAG
IS TEMP = 0 ?
Y
N
CALCULATE NORMALIZED TEMPERATURE CHANGE
IS THIS < ALLOWED ERROR ?
N
Y
MODIFY THE FLAG
SAVE THE CURRENT TEMPERATURES
RETURN
DO 50 H = 1, MAXNΦ


READ
A
CARD
IS
THE INPUT
IN CONDUCTANCE
FORM
?
SET A
FLAG
WRITE
THE
INFORMATION
WRITE
THE
INFORMATION
RETURN

ENTRY READ2


READ
A
CARD
WRITE
THE
INFORMATION
RETURN


IS TAB(2) = 0 ?
SET VALUE TO TAB(2)
RETURN
COMPARE THE ARGUMENT WITH NEXT INDEPENDENT VARIABLE
WRITE AN ERROR MESSAGE
IS THIS THE FIRST DEPENDENT VARIABLE ?
WHAT SIGN IS THE DIFFERENCE ?
IS THIS THE FIRST DEPENDENT VARIABLE ?
FIND VALUE BY INTERPOLATION
Y
(-)
(+)
N
(0)
IS THIS THE END OF THE TABLE ?
SET VALUE TO NEXT DEPENDENT VALUE
RETURN
IS TAB(1)≤0 ?
WRITE AN ERROR MESSAGE
SUBTRACT PERIODICITY FROM ARGUMENT

A P P E N D I X B

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        COMPILER OPTIONS - NAME=  TAP7,OPT=02,LINECNT=41,SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF
ISN 0002            COMMON/FUN1/ICATH,KC(50)
ISN 0003            COMMON/FUN2/IRAD,KR(250),EKR(250)
ISN 0004            COMMON/FUN3/IPHK,IPH(50),PHT1(50),PHH1(50),PHT2(50),PHH2(50)
ISN 0005            COMMON/FUN4/ICONK,ICON(100),EXCON(100),ACON(100)
ISN 0006            COMMON/FUN5/IRB1,POWFAC(100),NODEQ(100),Q0,IDELK
ISN 0007            COMMON/FUN6/IAER1,IAER2,IAERK,AER(51),IAER(50),I2AER(50),ALLOC(50)
ISN 0008            COMMON/FUN7/IKF,IAF2(250),IAF3(250),IAF4(250),FIAF5(250)
ISN 0009            COMMON/FUN8/IPK,IPR1(700),IPR2(700),PRUNT2(700)
ISN 0010            COMMON/FUN9/CO(20),PRTIME(5),TYM(5)
ISN 0011            COMMON/FUN10/KTHMAX,NEW(250),KLEAD(250),CFLUID(250),KTABLE(30),
                   *LTABLE(250),CFMIN(30),FULTIM(250)
ISN 0012            COMMON/FUN11/JOINMX,JTABLE(50),NUNODE(50),INNODE(50)
ISN 0013            COMMON/FUN12/MIX,KKTABL(30),LLEAD(200),LLTABL(200),LNEW(200),      T
                   1CSOLID(200)                                                        TAP11110
ISN 0014            COMMON/FUN14/F14,ERROR,NUTIME,ADTIME(20)                           TAP11140
ISN 0015            COMMON/TABNO/INDEX                                                 TAP11150
ISN 0016            COMMON/CRASH/SIGNAL
ISN 0017            COMMON/VARY/ NODVAR,IRVAR(999)
ISN 0018            REAL*8 CARD,TYP,   T,C,Q,PRINT,TR,RI,RC,TPREV,      COND,EX,TDIFF
ISN 0019            REAL*8 QBETA
ISN 0020            INTEGER*2 KC,KR,IPH,ICON,NODEQ,IAER,I2AER,IAF2,IAF3,IAF4,IPR1,
                   1IPR2,NEW,KLEAD,KTABLE,LTABLE,JTABLE,NUNODE,INNODE,KKTABL,LLEAD,
                   2LLTABL,LNEW,I2V,I3V,KIND,KDEP
ISN 0021            INTEGER*2 IRVAR,PRUNT2
ISN 0022            DIMENSION T(700),COND(999),C(700),TR(700),RI(700),RC(700),
                   1I2V(999),I3V(999),Q(700),WCP(30),TPREV(50),QBETA(100),
                   2TABLE(104,30),KIND(30),KDEP(30),QDEL(50),TITLE(18),PRUNT(700),
                   3 PRINT(3129,1)
ISN 0023            COMMON  PRINT                                                      TAP11310
ISN 0024            COMMON  TR     , RI     , RC     , I2V    , I3V                   TAP11320
ISN 0025            EQUIVALENCE (PRINT(1),COND(1)),(PRINT(1000),T(1))
                   1(PRINT(1700),C(1)),(PRINT(2400),Q(1)),(PRINT(3100),WCP(1))
ISN 0026            CALL READRE                                                        TAP11380
                    C
                    C  *****     FORMAT STATEMENTS *****
                    C
ISN 0027          1001 FORMAT (A5)
ISN 0028          1002 FORMAT(5X,I1,18A4)
ISN 0029          2001 FORMAT(1H1,10X,18A4/1H0)
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ISN 0030      2002 FORMAT(//9H0  TIME =,F 9.2,5X,6HRCMIN(,I4,3H) =,1PE11.5,5X,
                  *13HDELTA THETA =,1PE10.4)                                  TAP16620
ISN 0031      2003 FORMAT(//9H0  TIME =,F 9.2,5X,6HRCMIN(,I4,3H) =,1PE11.5,5X,
                  *13HDELTA THETA =,1PE10.4,5X,9HDELTA K =,F11.6)             TAP16660
ISN 0032      2004 FORMAT(/5(5X,A2,I4,1H=,1PE12.5))
ISN 0033      2010 FORMAT(1H0,15X,26HSTEADY STATE VALUES FOLLOW)
ISN 0034      3001 FORMAT(I5,10X,2E15.5)
ISN 0035      9001 FORMAT (25H0COMPUTING INTERVAL SMALLI8)
ISN 0036      9005 FORMAT(18HORCMIN ZERO, NODE=,I3)
ISN 0037      9010 FORMAT(10X,50('*')/5X,'THE JOB HAS BEEN CANCELLED BECAUSE OF A MAT
                  1HEMATICAL INSTABILITY IN THE FUNCTION INDICATED'/10X,'THE NEXT CAS
                  2E WILL NOW BE PROCESSED IF ONE EXISTS')
ISN 0038      9999 FORMAT(1H1,20X,40('*')/5X,'THE RUN HAS BEEN TERMINATED BECAUSE OF
                  1THE ERROR CONDITION NOTED')
              C
              C  INITIALIZE PROGRAM VARIABLES
              C
ISN 0039            DATA CARD/5HTITLE/                                        TAP11390
ISN 0040            LOGICAL SIGNAL                                            TAP11410
ISN 0041          1 READ (5,1001) TYP                                         TAP1143
ISN 0042            IF(TYP.NE.CARD) GO TO 1                                   TAP11450
ISN 0044            READ(99,1002) KPUNCH,TITLE                                TAP11460
ISN 0045            WRITE (6,2001) TITLE
ISN 0046            DO 2J=1,30                                                TAP11490
ISN 0047            CO(J)=0.
ISN 0048            KIND(J)=0.
ISN 0049            KDEP(J)=0.
ISN 0050            WCP(J)=0.
ISN 0051            KTABLE(J)=0.
ISN 0052            KKTABL(J)=0
ISN 0053            CFMIN(J)=1.E10
ISN 0054            DO 2I=1,104                                               T171148
ISN 0055          2 TABLE(I,J)=0.                                             TAP11500
ISN 0056            DO 3 I=1,5
ISN 0057            TYM(I)=0.                                                 TAP11520
ISN 0058          3 PRTIME(I)=0.                                              TAP11530
ISN 0059            DO 5 I=1,50
ISN 0060            QDEL(I)=0.                                                TAP11710
ISN 0061            NUNODE(I)=0                                               TAP11750
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ISN 0062          5 INNODE(I)=0
ISN 0063            DO 7 I=1,700
ISN 0064            T(I)=0.                                          TAP11910
ISN 0065            C(I)=0.
ISN 0066          7 Q(I)=0.
ISN 0067            DO 8 I=1,999
ISN 0068          8 COND(I)=0.
ISN 0069            SIGNAL=.TRUE.                                    TAP12120
                  C CLEAR CORE LOCATIONS                             TAP12180
ISN 0070            IERR=0
ISN 0071            MAXNO=0
ISN 0072            MAXNOR=0
ISN 0073            MINND=0
ISN 0074            KEY=0                                            TAP12350
ISN 0075            LL=1                                             TAP12360
ISN 0076            DELTAT=0.                                        TAP12370
ISN 0077            RCMIN=0.
ISN 0078            PRTST=0.0                                        TAP12390
ISN 0079            DELK=0.                                          TAP12420
ISN 0080            DBTOT=0.                                         TAP12430
ISN 0081            DTSAVE=0.
ISN 0082            NSTEP=1                                          TAP12450
ISN 0083            ISTEP=0
ISN 0084            LASTPR=1
ISN 0085            TOME=0.                                          TAP12470
ISN 0086            NODVAR=0
ISN 0087            MININT=0
ISN 0088            TYM(1)=1.E10                                     TAP12490
ISN 0089            PRTIME(1)=1.E10                                  TAP12500
                  C                                                  TAP12510
ISN 0090            CALL TRCIN(MAXNOR,I2V,I3V,COND,MAXNO,T,C,RI,TR)
                  C                                                  TAP12530
                  C READ IN FUNCTION DATA                            TAP12540
                  C                                                  TAP12550
ISN 0091            CALL FIN(T,I2V)
ISN 0092            IF(IRAD.GT.0.OR.ICONK.GT.0) NODVAR=1
ISN 0094            T2ME=C0(9)
                  C
                  C  SET THE INITIAL PRINT TIME
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ISN 0095          10 ISTEP=ISTEP+1
ISN 0096             IF(T2ME.GE.PRTIME(ISTEP)) GO TO 10
ISN 0098             PRNT=CO(ISTEP+15)
ISN 0099             CO(1)=PRNT
                  C                                                    TAP12610
                  C READ IN TABLES                                     TAP12620
                  C                                                    TAP12630
ISN 0100             CALL TABIN(TABLE,KDEP,KIND)                       TAP12640
ISN 0101             IF(.NOT.SIGNAL) GO TO 999
                  C                                                    TAP12660
ISN 0103             CALL REIX
                  C                                                    TAP12670
                  C SET UP BRANCHES FOR FUNCTION CALCULATIONS          TAP12680
                  C                                                    TAP12690
ISN 0104             IF (IRAD)121,121,120
ISN 0105          120 ASSIGN 301 TO NU2
ISN 0106             GO TO 122                                         TAP12750
ISN 0107          121 ASSIGN 305 TO NU2
ISN 0108          122 IF (ICONK)124,124,123
ISN 0109          123 ASSIGN 306 TO NU3
ISN 0110             GO TO 125                                         TAP12790
ISN 0111          124 ASSIGN 310 TO NU3
ISN 0112          125 IF (IRB1)127,127,126
ISN 0113          126 ASSIGN 237 TO NU4
ISN 0114             GO TO 128
ISN 0115          127 ASSIGN 240 TO NU4
ISN 0116          128 IF (IAERK)132,132,129
ISN 0117          129 IAERK=IAERK-1
ISN 0118             IF (IAER1)130,130,131
ISN 0119          130 ASSIGN 311 TO NU5
ISN 0120             ASSIGN 320 TO NU6
ISN 0121             GO TO 133                                         TAP12900
ISN 0122          131 ASSIGN 315 TO NU5
ISN 0123             ASSIGN 316 TO NU6
ISN 0124             GO TO 133                                         TAP12930
ISN 0125          132 ASSIGN 320 TO NU5
ISN 0126          133 IF (IKF)135,135,134
ISN 0127          134 ASSIGN 291 TO NU7
ISN 0128             GO TO 136                                         TAP12970
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ISN 0129        135 ASSIGN 300 TO NU7
ISN 0130        136 IF (ICATH)138,138,137
ISN 0131        137 ASSIGN 321 TO NU1
ISN 0132            GO TO 139                                          TAP13010
ISN 0133        138 ASSIGN 325 TO NU1
ISN 0134        139 IF (IPHK)142,142,140
ISN 0135        140 ASSIGN 326 TO NU8
ISN 0136            DO 141I=1,IPHK
ISN 0137            INDEX=IPH(I)                                       TAP13060
ISN 0138        141 TPREV(I)=T(INDEX)
ISN 0139            GO TO 150                                          TAP13080
ISN 0140        142 ASSIGN 335 TO NU8
ISN 0141        150 IF (KTHMAX)152,152,151                             TAP13100
ISN 0142        151 ASSIGN 230 TO NU10                                 TAP13110
ISN 0143            GO TO 155                                          TAP13120
ISN 0144        152 ASSIGN 231 TO NU10
ISN 0145        155 IF(JOINMX)157,157,156                              TAP13140
ISN 0146        156 ASSIGN 281 TO NU11                                 TAP13150
ISN 0147            GO TO 160                                          TAP13160
ISN 0148        157 ASSIGN 282 TO NU11
ISN 0149        160 IF(MIX) 162,162,161                                TAP13180
ISN 0150        161 ASSIGN 266 TO NU12
ISN 0151            GO TO 200
ISN 0152        162 ASSIGN 270 TO NU12
ISN 0153        200 ASSIGN 210 TO N2
ISN 0154            WRITE (6,2001) TITLE
ISN 0155            ASSIGN 330 TO NUT
                    C                                                  TAP13360
                    C GO TO BLOCK TO DO I/R AND T/R SUMMATION          TAP13370
                    C                                                  TAP13380
ISN 0156          205 CALL TRA(1)
                    C                                                  TAP13410
                    C  CALCULATE DELTAT FOR THIS INTERVAL
                    C  SET FLAGS TO PERFORM ONLY NECESSARY CALCULATIONS
                    C                                                  TAP13430
ISN 0157            GO TO N2,(210,216)
ISN 0158          210 DO 214 J=1,MAXNO
ISN 0159            IF(T(J)) 211,214,211
ISN 0160          211 IF(C(J)) 214,212,214
```

```
ISN 0161        212 T(J)=TR(J)/RI(J)                                          TAP13480
ISN 0162        214 CONTINUE
ISN 0163            ASSIGN 216 TO N2
ISN 0164            GO TO 400
ISN 0165        216 RCMIN=1.E10
ISN 0166            DO 220 J=1,MAXND
ISN 0167            IF(C(J)) 220,220,218
ISN 0168        218 RC(J)=C(J)/RI(J)
ISN 0169            IF(RC(J).GT.RCMIN) GO TO 220
ISN 0171            RCMIN=RC(J)
ISN 0172            MINND=J                                                   TAP13580
ISN 0173        220 CONTINUE
ISN 0174            IF(RCMIN.LE.0.) GO TO 905
                C
                C  IF DELTAT IS PRESELECTED, ESTABLISH WHICH DELTAT IS CURRENTLY USED
                C  IF DELTAT IS TO BE AUTOMATICALLY SELECTED, DELTAT=RCMIN
                C
ISN 0176            IF(CO(2)) 225,225,223
ISN 0177        223 IF(T2ME.GE.TYM(NSTEP)) NSTEP=NSTEP+1
ISN 0179            DELTAT=CO(NSTEP+10)
ISN 0180            IF(DELTAT.GT.RCMIN) GO TO 225
ISN 0182            GO TO 228
ISN 0183        225 DELTAT=RCMIN
ISN 0184            IF(CO(3)) 228,228,227
ISN 0185        227 DELTAT=CO(3)*DELTAT
ISN 0186        228 IF(CO(10)-DELTAT) 229,229,900
                C                                                             TAP13750
                C   PERFORM FLUID FLOW CALCULATIONS (FUNCTION 10)
                C                                                             TAP13770
ISN 0187        229 GO TO NU10,(230,231)
ISN 0188        230 CALL FLOW(TOME,WCP,T2ME,TABLE,DELTAT,T,C,RI,RCMIN,IERR)
ISN 0189            IF(IERR.EQ.1) GO TO 910
ISN 0191            IF(.NOT.SIGNAL) GO TO 999
                C
                C  CHECK TO DETERMINE IF A PRINT IS REQUIRED ON THIS ITERATION
                C
ISN 0193        231 IF(T2ME.LE.PRTIME(ISTEP)) GO TO 232
ISN 0195            ISTEP=ISTEP+1
ISN 0196            LASTPR=1
```

```
ISN 0197            PRTST=0.
ISN 0198            CO(1)=CO(ISTEP+15)
ISN 0199            PRNT=PRTIME(ISTEP-1)+CO(1)
ISN 0200        232 PRTST=-T2ME-DELTAT+PRNT
ISN 0201            IF(PRTST) 233,234,235
ISN 0202        233 DELTAT=DELTAT+PRTST
ISN 0203        234 LASTPR=LASTPR+1
ISN 0204            ADD=LASTPR
ISN 0205            PRNT=ADD*CO(1)
ISN 0206            IF(ISTEP.GT.1) PRNT=PRNT+PRTIME(ISTEP-1)
ISN 0208            PRTST=0.
ISN 0209        235 TFLAG=1.0
ISN 0210            GO TO NU4, (237,240)
                C                                                          TAP14120
                C  CALL IN THE HEATING FUNCTION
                C                                                          TAP14140
ISN 0211        237 CALL HEATIN(T2ME,TABLE,QBETA,T,Q,DBTCT)
ISN 0212            IF(.NOT.SIGNAL) GO TO 999
                C
                C  NOW PERFORM THE PRIMARY TEMPERATURE CALCULATIONS
                C
ISN 0214        240 DO 245 J=1,MAXNO
ISN 0215            IF(T(J)) 241,245,241
ISN 0216        241 IF(C(J)) 245,242,244
ISN 0217        242 TFLAG=0.0
ISN 0218            GO TO 245
ISN 0219        244 T(J)=   DELTAT/C(J)*(Q(J)+TR(J)-T(J)*RI(J))+T(J)
ISN 0220            IF(T(J).EQ.0.) T(J)=0.001
ISN 0222        245 CONTINUE
ISN 0223            IF(TFLAG) 256,256,265
                C                                                          TAP14670
                C GO TO INSTR BLOCK TO DO I/R AND T/R SUMMATION FOR SECOND PASS THIS   TAP14680
                C  INTERVAL TO RELAX ZERO CAPACITANCE NODES.               TAP14690
                C                                                          TAP14700
ISN 0224        256 CALL TRA(2)
ISN 0225            DO 260 J=1,MAXNO
ISN 0226            IF(T(J)) 257,260,257
ISN 0227        257 IF(C(J)) 260,258,260
ISN 0228        258 T(J)=(Q(J)+TR(J))/RI(J)
```

```
ISN 0229          IF (T(J)) 260,259,260
ISN 0230       259 T(J)=.0001
ISN 0231       260 CONTINUE
                   C                                                              TAP14800
                   C     MOVEMENT OF FLUID THROUGH A SERIES OF NODES IN ONE TIME INCREMENT TAP14810
                   C                                                              TAP14820
ISN 0232       265 GO TO NU12,(266,270)
ISN 0233       266 CALL FSTFLO(TOME,WCP,T2ME,TABLE,DELTAT,T,C,Q,TR,RI,RCMIN,IERR)
ISN 0234          IF(IERR.EQ.1) GO TO 910
ISN 0236          IF(.NOT.SIGNAL) GO TO 999
                   C
                   C  COMPLETE THIS ITERATION BY UPDATING THE PROBLEM TIME
                   C
ISN 0238       270 T2ME=T2ME+DELTAT
                   C
                   C CHECK FOR STEADY STATE
                   C
ISN 0239          IF(F14.NE. 1.) GO TO 280
ISN 0241          CALL STEADY(KEY,T,MAXNO,DELTAT)                              TAP15080
ISN 0242          IF(KEY.EQ.0) GO TO 280
ISN 0244          WRITE(6,2010)
ISN 0245          IF(NUTIME.EQ.0) GO TO 273
ISN 0247       271 IF(T2ME.LT.ADTIME(LL)) GO TO 272
ISN 0249          LL=LL+1                                                      TAP15130
ISN 0250          GO TO 271
ISN 0251       272 T2ME=ADTIME(LL)
ISN 0252          LL=LL+1
ISN 0253          IF(LL.GT.NUTIME) NUTIME=0                                    TAP15170
ISN 0255          GO TO 400
ISN 0256       273 T2ME=CO(4)+1.
ISN 0257          GO TO 400
                   C                                                              TAP15220
                   C  TEMPERATURE AVERAGING SCHEME FOR ADJOINING NODES            TAP15230
                   C                                                              TAP15240
ISN 0258       280 GO TO NU11,(281,282)
ISN 0259       281 CALL TAVG(TOME,C,T,WCP,DELTAT,RI,RCMIN,IERR)
ISN 0260          IF(IERR.EQ.1) GO TO 910
ISN 0262       282 TOME=1.
ISN 0263          IF(PRTST.EQ. 0.) GO TO 400
```

```
                C                                                                TAP15480
                C     EVALUATION OF ALL VARIABLE GS,TS,RS AND CS AT EACH TIME INCREM.  TAP15490
                C                                                                TAP15500
ISN 0265          290 DTSAVE=DELTAT
ISN 0266              GO TO NU7, (291,300)
                C                                                                TAP15520
                C     PERFORM ARBITRARY FUNCTIONS INTERPOLATIONS                  TAP15530
                C                                                                TAP15540
ISN 0267          291 DO 297 I=1,IKF
ISN 0268              J=IAF2(I)                                                  TAP15560
ISN 0269              L=IAF3(I)                                                  TAP15570
ISN 0270              INDEX=IAF4(I)                                              TAP15580
ISN 0271              M=KIND(INDEX)                                              TAP15590
ISN 0272              NYS=KDEP(INDEX)                                            TAP15600
ISN 0273              MA = (NYS-1)*999 + J
ISN 0274              IF(NYS.GT.2) MA=MA-(NYS-2)*299
ISN 0276              MB = (M-1) * 999 + L
ISN 0277              IF(M.GT.2) MB=MB-(M-2)*299
ISN 0279              MC=(INDEX-1)*104+1                                         TAP15630
ISN 0280              IF (M)294,294,293
ISN 0281          293 PRINT(MA,1)=ENTERP(PRINT(MB,1),TABLE(MC,1))
ISN 0282              IF(M.EQ.1) PRINT(MA,1)=1.0/PRINT(MA,1)
ISN 0284              GO TO 295
ISN 0285          294 PRINT(MA,1)=ENTERP(T2ME,TABLE(MC,1))
ISN 0286          295 IF(.NOT.SIGNAL) GO TO 999
ISN 0288              IF(FIAF5(I)) 296,297,296
ISN 0289          296 PRINT(MA,1)=FIAF5(I)*PRINT(MA,1)
ISN 0290          297 CONTINUE
ISN 0291          300 GO TO NU2,(301,305)
                C                                                                TAP15740
                C COMPUTE RADIATION RESISTORS                                    TAP15750
                C                                                                TAP15760
ISN 0292          301 DO 302 I=1,IRAD
ISN 0293              INDEX=KR(I)                                                TAP15780
ISN 0294              K2=I2V(INDEX)                                              TAP15790
ISN 0295              K3=I3V(INDEX)                                              TAP15800
ISN 0296              COND(INDEX)=(EKR(I)*((T(K2)+459.69)**2+(T(K3)+459.69)**2)*((T(K2)+
                     &459.69)+(T(K3)+459.69)))
ISN 0297          302 CONTINUE
```

```
ISN 0298        305 GO TO NU3,(306,310)
                C                                                              TAP15860
                C COMPUTE CONVECTION RESISTORS                                 TAP15870
                C                                                              TAP15880
ISN 0299        306 G=ENTERP(T2ME,TABLE(1,2))
ISN 0300            IF(.NOT.SIGNAL) GO TO 999
ISN 0302            DO 307 I=1,ICONK
ISN 0303            INDEX=ICON(I)                                              TAP15920
ISN 0304            K2=I2V(INDEX)                                              TAP15930
ISN 0305            K3=I3V(INDEX)                                              TAP15940
ISN 0306            EX=EXCON(I)                                                TAP15950
ISN 0307            TDIFF=DABS(T(K2)-T(K3))                                    TAP15960
ISN 0308            COND(INDEX)=(G*ENTERP((T(K2)+T(K3))/2.0,TABLE(1,1))*ACON(I)*
                   &SNGL(TDIFF**EX))
ISN 0309            IF(.NOT.SIGNAL) GO TO 999
ISN 0311        307 CONTINUE
ISN 0312        310 GO TO NU5,(311,315,320)
                C                                                              TAP16030
                C COMPUTE AERODYNAMIC HEATING USING THE ECKERT METHOD          TAP16040
                C                                                              TAP16050
ISN 0313        311 FLAG=0.0
ISN 0314            DO 314 I=1,IAERK
ISN 0315            INDEX=IAER(I)                                              TAP16080
ISN 0316            Q(INDEX)=                                                  TAP16090
                   1     QECK(T2ME,FLAG,T(INDEX),                              TAP16100
                   2                    TABLE(1,3),TABLE(1,4),TABLE(1,11),    TAP16110
                   1TABLE(1,12),TABLE(1,5),TABLE(1,8),IAER2,I2AER(I),ALLOC(I), TAP16120
                   2TABLE(1,9),TABLE(1,10),TABLE(1,6),CO(5),CC(6),CC(7),CO(8), TAP16130
                   3TABLE(1,7),AER(I))                                         TAP16140
ISN 0317            IF(.NOT.SIGNAL) GO TO 999
ISN 0319        314 CONTINUE
ISN 0320        315 GO TO NU6,(316,320)
                C                                                              TAP16180
                C COMPUTE AERO HEATING USING RAMO-WOOLDRIDGE METHOD            TAP16190
                C                                                              TAP16200
ISN 0321        316 FLAG=0.0
ISN 0322            DO 318 I=1,IAERK
ISN 0323            INDEX=IAER(I)                                              TAP16230
ISN 0324            Q(INDEX)=
```

```
                     1      ORW(T2ME,FLAG,IAER2,T(INDEX),                                  TAP16250
                     2                          TABLE(1,3),TABLE(1,4),TABLE(1,11),         TAP16260
                     1CO(5),CO(6),CO(7),CO(8),AER(I),TABLE(1,5),                           TAP16270
                     2  I2AER(I),ALLOC(I),                                                 TAP16280
                     3TABLE(1,6),TABLE(1,12))                                              TAP16290
ISN 0325              IF(.NOT.SIGNAL) GO TO 999
ISN 0327           318  CONTINUE
ISN 0328           320 GO TO NU1,(321,325)
                   C                                                                      TAP16330
                   C PERFORM CATHODE FOLLOWER COMPUTATION                                 TAP16340
                   C                                                                      TAP16350
ISN 0329           321 DO 322 I=2,ICATH,2
ISN 0330              K1=KC(I-1)                                                          TAP16370
ISN 0331              K2=KC(I)                                                            TAP16380
ISN 0332           322 T(K1)=T(K2)
ISN 0333           325 GO TO NU8,(326,335)
                   C                                                                      TAP16410
                   C COMPUTE LATENT HEAT EFFECTS                                          TAP16420
                   C                                                                      TAP16430
ISN 0334           326 DO 327 I=1,IPHK
ISN 0335              INDEX=IPH(I)                                                        TAP16450
ISN 0336           327 CALL LAT(PHT1(I),PHH1(I),PHT2(I),PHH2(I),QDEL(I),T(INDEX),         TAP16460
                     1                                                  TPREV(I),         TAP16470
                     2Q(INDEX),RI(INDEX),TR(INDEX),DELTAT,T2ME,INDEX)
ISN 0337              IF(.NOT.SIGNAL) GO TO 999
ISN 0339              GO TO 335
                   C                                                                      TAP16700
                   C TEST FOR END OF JOB                                                  TAP16710
                   C                                                                      TAP16720
ISN 0340           330 CONTINUE
ISN 0341              ASSIGN 290 TO NUT
ISN 0342              IF(TOME.EQ. 0.) GO TO 290
ISN 0344              IF(MININT-1) 335,1,335
ISN 0345           335 IF(T2ME-CO(4))205,336,336
ISN 0346           336 CONTINUE
ISN 0347              IF(KPUNCH.NE. 1) GO TO 1                                            TAP16780
ISN 0349              DO 340 I=1,MAXNO
ISN 0350              IF(T(I).EQ. 0.) GO TO 340
ISN 0352              WRITE(7,3001) I,T(I),C(I)
```

```
ISN 0353        340 CONTINUE
ISN 0354            GO TO 1                                                    TAP16840
                C                                                              TAP16510
                C       SET UP PRINT BLOCK FOR OUTPUT                          TAP16520
                C                                                              TAP16530
ISN 0355        400 DO 402 I=1,IPK
ISN 0356            J=IPR1(I)                                                  TAP16550
ISN 0357            M=(J-1)*999+IPR2(I)
ISN 0358            IF(J.GT.2) M=M-(J-2)*299
ISN 0360        402 PRUNT(I)=PRINT(M,1)
ISN 0361            IF(DELK.NE. 0.) GO TO 405
ISN 0363            WRITE (6,2002) T2ME,MINND,RCMIN,DTSAVE
ISN 0364            GO TO 410
ISN 0365        405 WRITE(6,2003) T2MF,MINND,RCMIN,DTSAVE,DELK
ISN 0366        410 WRITE (6,2004) (PRUNT2(I),IPR2(I),PRUNT(I),I=1,IPK)
ISN 0367            GO TO NUT,(330,290)
                C
                C   *****   ERROR ROUTINES   *****
                C
ISN 0368        900 WRITE (6,9001) MINND
ISN 0369            MININT=1
ISN 0370            GO TO 400
ISN 0371        905 WRITE (6,9005) MINND
ISN 0372            GO TO 1                                                    TAP13630
ISN 0373        910 WRITE (6,9010)
ISN 0374            GO TO 1
ISN 0375        999 WRITE(6,9999)
ISN 0376            GO TO 1
ISN 0377            END                                                        TAP16890
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        COMPILER OPTIONS - NAME=  TAP7,OPT=02,LINECNT=41,SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF
ISN 0002            SUBROUTINE TRCIN(MAXNOR,I2V,I3V,COND,MAXNO,T,C,RI,TR)
                  C THIS SUBROUTINE READS IN ALL RESISTOR, TEMPERATURE, CAPACITOR DATA     TRCI1040
                  C                                                                       TRCI1050
ISN 0003            REAL*8 COND,T,C,RI,TR
ISN 0004            REAL*8 RIFIX(700)
ISN 0005            INTEGER*2 I2V,I3V
ISN 0006            INTEGER*2 IRVAR
ISN 0007            COMMON/CRASH/SIGNAL
ISN 0008            COMMON/VARY/ NODVAR,IRVAR(999)
ISN 0009            COMMON/FLAG/ KFLAG
ISN 0010            DIMENSION I(3),I2V(999),I3V(999),COND(999),T(700),C(700),RI(700),
                   1TR(700)
ISN 0011            EQUIVALENCE(I(1),I1),(I(2),I2),(I(3),I3)                            TRCI1100
ISN 0012            DATA CSET/'COND'/,CCHECK/'C'/
                  C                                                                     TRCI1110
                  C READ RESISTOR DATA                                                  TRCI1120
                  C                                                                     TRCI1130
ISN 0013            KFLAG=-1
ISN 0014            DO 1 J1=1,999
ISN 0015          1 I2V(J1)=0                                                           TRCI1150
                  C                                                                     TRCI1160
ISN 0016            READ(5,1002) CON
ISN 0017            IF(CON.NE.CSET) GO TO 2
ISN 0019            KFLAG=1
ISN 0020            GO TO 10
ISN 0021          2 READ(99,1003) CON,I,RIN
ISN 0022            WRITE(6,1003) CON,I,RIN
ISN 0023            IF(CON.EQ.CCHECK) KFLAG=0
ISN 0025            GO TO 11
ISN 0026         10 CALL READ(I,RIN)
ISN 0027         11 IF(I2.LT.0.OR.I3.LT.0) GO TO 20
ISN 0029            MAXNOR=MAXO(MAXNOR,I1)                                              TRCI1190
ISN 0030            IF(I1) 50,50,15                                                     TRCI1200
ISN 0031         15 M=I1                                                                TRCI1210
ISN 0032            I2V(M )=I2                                                          TRCI1220
ISN 0033            I3V(M )=I3                                                          TRCI1230
ISN 0034            COND(M)=1.0/RIN
```

```
ISN 0035          IF(KFLAG.GE.0) COND(M)=RIN
ISN 0037          IF(KFLAG.EQ.0) KFLAG=-1
ISN 0039          GO TO 10                                          TRCI1250
ISN 0040       20 K1=I1                                             TRCI1260
ISN 0041          K2SAVE=I2
ISN 0042          K3SAVE=I3
ISN 0043          IF(I2.LT.0) K2=-I2
ISN 0045          IF(I3.LT.0) K3=-I3
ISN 0047          CALL READ(I,RIN)
ISN 0048          MAXNOR=MAXO(MAXNOR,I1)                            TRCI1300
ISN 0049          K1MAX=I1                                          TRCI1310
ISN 0050          K2I=K2-K1                                         TRCI1320
ISN 0051          K3I=K3-K1                                         TRCI1330
ISN 0052          DO 25 J=K1,K1MAX                                  TRCI1340
ISN 0053          I2V(J)=K2I+J                                      TRCI1350
ISN 0054          IF(K2SAVE.GT.0) I2V(J)=K2SAVE
ISN 0056          I3V(J)=K3I+J                                      TRCI1360
ISN 0057          IF(K3SAVE.GT.0) I3V(J)=K3SAVE
ISN 0059          COND(J)=1.0/RIN
ISN 0060          IF(KFLAG.GE.0) COND(J)=RIN
ISN 0062          IF(J.EQ.K1.OR.J.EQ.K1MAX) GO TO 25                TRCI1380
ISN 0064          WRITE (6,1000) J,I2V(J),I3V(J),RIN                TRCI1390
ISN 0065       25 CONTINUE                                          TRCI1400
ISN 0066          IF(KFLAG.EQ.0) KFLAG=-1
ISN 0068          GO TO 10                                          TRCI1410
ISN 0069       50 IF(MAXNOR.LE.999) GO TO 51
ISN 0071          WRITE(6,2001)
ISN 0072          SIGNAL=.FALSE.
                  C                                                 TRCI1420
                  C READ TEMPERATURE AND CAPACITOR DATA             TRCI1430
                  C                                                 TRCI1440
ISN 0073       51 CALL READ2(I,TIN,CIN)
                  C                                                 TRCI1460
                  C     TEST FOR ZERO INPUT T AND CHANGE TC .0001   TRCI1470
                  C                                                 TRCI1480
ISN 0074          IF(I2.LT. 0) GO TO 70                             TRCI1490
ISN 0076          IF(TIN.EQ. 0) TIN=.0001                           TRCI1500
ISN 0078          MAXNO=MAXO(MAXNO,I1)                              TRCI1510
ISN 0079          IF(I1) 80,80,60
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ISN 0080          60 M=I1                                                    TRCI1530
ISN 0081             T(M)=TIN                                                TRCI1540
ISN 0082             C(M)=CIN                                                TRCI1550
ISN 0083             GO TO 51
ISN 0084          70 K1=I1                                                   TRCI1570
ISN 0085             CALL READ2(I,TIN,CIN)                                   TRCI1580
ISN 0086             MAXNO=MAXO(MAXNO,I1)                                    TRCI1590
ISN 0087             K1MAX=I1                                                TRCI1600
ISN 0088             IF(TIN.EQ. 0) TIN=.0001                                 TRCI1610
ISN 0090             DO 75 J=K1,K1MAX                                        TRCI1620
ISN 0091             T(J)=TIN                                                TRCI1630
ISN 0092             C(J)=CIN                                                TRCI1640
ISN 0093             IF(J.EQ.K1.OR.J.EQ.K1MAX) GO TO 75                      TRCI1650
ISN 0095             WRITE (6,1001) J,TIN,CIN                                TRCI1660
ISN 0096          75 CONTINUE                                                TRCI1670
ISN 0097             GO TO 51
ISN 0098          80 IF(MAXNO.LE.700) GO TO 81
ISN 0100             WRITE(6,2006)
ISN 0101             SIGNAL=.FALSE.
ISN 0102             RETURN
                  C
                  C  CHECK TO SEE IF ANY CONDUCTORS ARE ATTACHED TO NON-EXISTENT NODES OR
                  C  IF ANY SPECIFIED NODES ARE NOT ATTACHED TO CONDUCTORS
                  C
ISN 0103          81 DO 83 J=1,MAXNOR
ISN 0104             IF(I2V(J).EQ.0) GO TO 83
ISN 0106             NODE1=I2V(J)
ISN 0107             NODE2=I3V(J)
ISN 0108             RI(NODE1)=1.
ISN 0109             RI(NODE2)=1.
ISN 0110             IF(T(NODE1).NE.0.) GO TO 82
ISN 0112             WRITE(6,9001) J,NODE1
ISN 0113             SIGNAL=.FALSE.
ISN 0114          82 IF(T(NODE2).NE.0.) GO TO 83
ISN 0116             WRITE(6,9001) J,NODE2
ISN 0117             SIGNAL=.FALSE.
ISN 0118          83 CONTINUE
ISN 0119             DO 84 J=1,MAXNO
ISN 0120             IF(T(J).EQ.0.) GO TO 84
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ISN 0122            IF(RI(J).NE.0.) GO TO 84
ISN 0124            IF(C(J).LT.0.) GO TO 84
ISN 0126            WRITE(6,9002) J
ISN 0127            SIGNAL=.FALSE.
ISN 0128         84 CONTINUE
ISN 0129            RETURN
                 C
                 C SECTION RFIX IS TO SET THE 1/R SUMS FOR THE NODES WITH FIXED RESISTORS
                 C
ISN 0130            ENTRY RFIX
ISN 0131            DO 85 J=1,MAXNO
ISN 0132            RI(J)=0.
ISN 0133         85 RIFIX(J)=0.
ISN 0134            DO 95 J=1,MAXNOR
ISN 0135            IF(I2V(J)) 88,95,88
ISN 0136         88 L=IRVAR(J)
ISN 0137            IF(L) 95,91,95
ISN 0138         91 NODE1=I2V(J)
ISN 0139            NODE2=I3V(J)
ISN 0140            RIFIX(NODE1)=RIFIX(NODE1)+COND(J)
ISN 0141            RIFIX(NODE2)=RIFIX(NODE2)+COND(J)
ISN 0142         95 CONTINUE
ISN 0143            DO 100 J=1,MAXNO
ISN 0144        100 RI(J)=RIFIX(J)
ISN 0145            RETURN
                 C                                                          TRCI1700
                 C SECTION TRA IS TO ESTABLISH THE 1/R AND T/R SUMS FOR ALL NODES
                 C                                                          TRCI1720
ISN 0146            ENTRY TRA(IPASS)
ISN 0147            IF(NODVAR) 103,111,103
ISN 0148        103 GO TO (105,130),IPASS
ISN 0149        105 DO 110 J=1,MAXNOR
ISN 0150            IF(IRVAR(J)) 110,110,106
ISN 0151        106 K=IRVAR(J)
ISN 0152            NODE1=I2V(K)
ISN 0153            NODE2=I3V(K)
ISN 0154            RI(NODE1)=RIFIX(NODE1)
ISN 0155            RI(NODE2)=RIFIX(NODE2)
ISN 0156        110 CONTINUE
```

```
ISN 0157        111 DO 120 J=1,MAXNO
ISN 0158            TR(J)=0.0
ISN 0159        120 CONTINUE
ISN 0160            DO 125 J=1,MAXNOR
ISN 0161            IF(I2V(J)) 122,125,122
ISN 0162        122 NODE1=I2V(J)
ISN 0163            NODE2=I3V(J)
ISN 0164            IF(IRVAR(J)) 123,124,123
ISN 0165        123 RI(NODE1)=RI(NODE1)+COND(J)
ISN 0166            RI(NODE2)=RI(NODE2)+COND(J)
ISN 0167        124 TR(NODE1)=TR(NODE1)+COND(J)*T(NODE2)
ISN 0168            TR(NODE2)=TR(NODE2)+COND(J)*T(NODE1)
ISN 0169        125 CONTINUE
ISN 0170            RETURN
ISN 0171        130 DO 131 J=1,MAXNO
ISN 0172            IF(C(J).EQ.0.) TR(J)=0.
ISN 0174        131 CONTINUE
ISN 0175            DO 140 J=1,MAXNOR
ISN 0176            IF(I2V(J)) 132,140,132
ISN 0177        132 NODE1=I2V(J)
ISN 0178            NODE2=I3V(J)
ISN 0179            IF(C(NODE1)) 136,134,136
ISN 0180        134 TR(NODE1)=TR(NODE1)+COND(J)*T(NODE2)
ISN 0181        136 IF(C(NODE2)) 140,138,140
ISN 0182        138 TR(NODE2)=TR(NODE2)+COND(J)*T(NODE1)
ISN 0183        140 CONTINUE
ISN 0184            RETURN
ISN 0185       1000 FORMAT(1X,3I5,E15.5,' ** GENERATED NODE **')
ISN 0186       1001 FORMAT(1X,I5,10X,2E15.5,' ** GENERATED NODE **')
ISN 0187       1002 FORMAT(A4)
ISN 0188       1003 FORMAT(A1,I4,2I5,E15.5)
ISN 0189       2001 FORMAT(20X,40('*')/5X,'AT LEAST ONE OF THE RESISTORS HAS A NUMBER
                   1GREATER THAN 999'/5X,'CHECK THE INPUT AND MAKE THE NECESSARY CORRE
                   2CTIONS')
ISN 0190       2006 FORMAT(20X,40('*')/5X,'AT LEAST ONE OF THE NODES HAS A NUMBER GREA
                   1TER THAN 700'/5X,'CHECK THE INPUT AND MAKE THE NECESSARY CORRECTIO
                   2NS')
ISN 0191       9001 FORMAT(20X,40('*')/5X,'RESISTOR OR CONDUCTOR',I4,' IS ATTACHED TO
                   1A NODE (',I3,')'/5X,'FOR WHICH NEITHER THE TEMPERATURE NOR THE CAP
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                2ACITANCE HAS BEEN SPECIFIED')
ISN 0192        9002 FORMAT(20X,40('*')/5X,'THE TEMPERATURE AND CAPACITANCE FOR NODE',
                1I4,' HAVE BEEN SPECIFIED,'/5X,'BUT THEY ARE NOT ATTACHED TC ANY RE
                2SISTOR OR CONDUCTOR')
ISN 0193         END                                                    TRCI1900
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COMPILER OPTIONS - NAME=  TAP7,OPT=02,LINECNT=41,SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF
ISN 0002            SUBROUTINE FIN(T,I2V)
                    C FIN                                                          FIN 1060
                    C THIS SUBROUTINE READS IN ALL FUNCTION DATA                   FIN 1070
                    C                                                              FIN 1080
ISN 0003            COMMON/FUN1/ICATH,KC(50)
ISN 0004            COMMON/FUN2/IRAD,KR(250),EKR(250)
ISN 0005            COMMON/FUN3/IPHK,IPH(50),PHT1(50),PHH1(50),PHT2(50),PHH2(50)
ISN 0006            COMMON/FUN4/ICONK,ICON(100),EXCON(100),ACON(100)
ISN 0007            COMMON/FUN5/IRB1,POWFAC(100),NODEQ(100),Q0,IDELK
ISN 0008            COMMON/FUN6/IAER1,IAER2,IAERK,AER(51),IAER(50),I2AER(50),ALLOC(50)
ISN 0009            COMMON/FUN7/IKF,IAF2(250),IAF3(250),IAF4(250),FIAF5(250)
ISN 0010            COMMON/FUN8/IPK,IPR1(700),IPR2(700),PRUNT2(700)
ISN 0011            COMMON/FUN9/CO(20),PRTIME(5),TYM(5)
ISN 0012            COMMON/FUN10/KTHMAX,NEW(250),KLEAD(250),CFLUID(250),KTABLE(30),
                   *LTABLE(250),CFMIN(30),FULTIM(250)
ISN 0013            COMMON/FUN11/JOINMX,JTABLE(50),NUNODE(50),INNODE(50)
ISN 0014            COMMON/FUN12/MIX,KKTABL(30),LLEAD(200),LLTABL(200),LNEW(200),
                    1CSOLID(200)                                                   FIN 1140
B-20
ISN 0015            COMMON/FUN13/NBASE(3),RHO(3),TBASE(3),CBWAIT,NDEADB,DELKDB,DELTDB,FIN 1150
                    &TDEADB                                                        FIN 1160
ISN 0016            COMMON/FUN14/F14,ERROR,NUTIME,ADTIME(20)                       FIN 1170
ISN 0017            COMMON/VARY/ NODVAR,IRVAR(999)
ISN 0018            INTEGER*2 KC,KR,IPH,ICON,NODEQ,IAER,I2AER,IAF2,IAF3,IAF4,IPR1,
                    1IPR2,NEW,KLEAD,KTABLE,LTABLE,JTABLE,NUNODE,INNODE,KKTABL,LLEAD,
                    2LLTABL,LNEW
ISN 0019            INTEGER*2 IRVAR,HOL,PRUNT2,I2V
ISN 0020            REAL*8 T
ISN 0021            COMMON/CRASH/SIGNAL
ISN 0022            DIMENSION I(3),HOL(4)
ISN 0023            DIMENSION T(700),I2V(999)
ISN 0024            EQUIVALENCE(I(1),I1),(I(2),I2),(I(3),I3)                       FIN 1310
ISN 0025            DATA HOL/8HK-T-C-Q-/
                    C
                    C    **********      FORMAT STATEMENTS      **********
                    C
ISN 0026             2001 FORMAT(2X,'THE NODES WITHIN THE RANGE OF THE LAST TWO CARDS CONTAI
                         IN THE SAME INFORMATION AS THESE CARDS')
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ISN 0027        2002 FORMAT(2X,'NODES',I4,' TO',I4,' HAVE BEEN GENERATED INTERNALLY.'/
                    12X,'THE INFORMATION IS THE SAME AS SHOWN FOR NODE',I4)
ISN 0028        9003 FORMAT(20X,40('*')/5X,'YOU HAVE LESS THAN FOUR PIECES OF INFORMATI
                    1ON FOR PHASE TRANSITION AT ONE NODE')
ISN 0029        9006 FORMAT(20X,40('*')/5X,'YOU HAVE ENTERED THE DATA FOR THE AERODYNAM
                    1IC HEATING ROUTINE INCORRECTLY')
ISN 0030        9010 FORMAT(20X,40('*')/5X,'YOU HAVE USED ZERO AS ONE OF THE TABLE NUMB
                    1ERS')
ISN 0031        9011 FORMAT(20X,40('*')/5X,'YOU HAVE FORGOTTEN TO SPECIFY ANY OUTPUT')
ISN 0032        9012 FORMAT(20X,40('*')/5X,'YOU HAVE NEGLECTED TO SPECIFY A PRINT INTER
                    1VAL')
ISN 0033        9013 FORMAT(20X,40('*')/5X,'YOU HAVE FORGOTTEN TO SPECIFY A PROBLEM COM
                    1PLETION TIME')
ISN 0034        9100 FORMAT(20X,40('*')/5X,'YOU ARE CALLING FOR A NON-EXISTENT FUNCTION
                    1 NUMBER',I3)
ISN 0035        9110 FORMAT(20X,40('*')/5X,'NODE',I4,' SPECIFIED IN FUNCTION',I3,' IS N
                    1ON-EXISTENT')
ISN 0036        9111 FORMAT(20X,40('*')/5X,'RESISTOR OR CONDUCTOR',I4,' SPECIFIED IN FU
                    1NCTION',I3,' IS NON-EXISTENT')
ISN 0037        9115 FORMAT(20X,40('*')/5X,'EITHER NODE'I4,' OR',I4,' SPECIFIED IN FUNC
                    1TION',I3,' IS NON-EXISTENT')
ISN 0038        9150 FORMAT(20X,40('*')/5X,'YOU HAVE USED MORE PIECES OF DATA IN FUNCTI
                    1ON',I3,' THAN THE PROGRAM ALLOWS.'/5X,'CHECK TO SEE THAT YOU DID N
                    2OT OMIT A -1 AT THE END OF A PREVIOUS FUNCTION')
                C
ISN 0039            DO 5 J=1,999
ISN 0040          5 IRVAR(J)=0
ISN 0041            ICATH=0                                                  TAP12190
ISN 0042            IRAD=0                                                   TAP12200
ISN 0043            IPHK=0                                                   TAP12210
ISN 0044            ICONK=0                                                  TAP12220
ISN 0045            IRB1=0                                                   TAP12230
ISN 0046            IAERK=0                                                  TAP12260
ISN 0047            IKF=0                                                    TAP12270
ISN 0048            IPK=0                                                    TAP12280
ISN 0049            NDEADB=0
ISN 0050            KTHMAX=0                                                 TAP12310
ISN 0051            JOINMX=0                                                 TAP12320
ISN 0052            MIX=0                                                    TAP12330
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ISN 0053            ISTEP=0                                                  FIN 1340
ISN 0054            NSTEP=0                                                  FIN 1350
ISN 0055            PRMAX=0.                                                 FIN 1360
ISN 0056            TIMMAX=0.                                                FIN 1370
ISN 0057            F14=0.                                                   FIN 1380
ISN 0058            NUTIME=0                                                 FIN 1390
ISN 0059            LOGICAL SIGNAL                                           FIN 1400
ISN 0060          1 CALL READ(I,FD,FD2)
ISN 0061            IF(I1) 500,500,2
ISN 0062          2 IF(I1-1) 10,10,19
                  C                                                          FIN 1440
                  C READ IN CATHODE FOLLOWER DATA, FUNCTION 1                FIN 1450
                  C                                                          FIN 1460
ISN 0063         10 IFUN=1
ISN 0064            KC(ICATH+1)=I2
ISN 0065            KC(ICATH+2)=I3                                           FIN 1480
ISN 0066            IF(T(I2).NE.0.) GO TO 11
ISN 0068            WRITE(6,9110) I2,IFUN
ISN 0069            SIGNAL=.FALSE.
ISN 0070         11 IF(T(I3).NE.0.) GO TO 12
ISN 0072            WRITE(6,9110) I3,IFUN
ISN 0073            SIGNAL=.FALSE.
ISN 0074         12 ICATH=ICATH+2
ISN 0075            IF(ICATH.GT.52) GO TO 515
ISN 0077            CALL READ (I,FD)                                         FIN 1500
ISN 0078            IF(I1) 1,10,2
ISN 0079         19 IF(I1-2) 20,20,29
                  C                                                          FIN 1530
                  C READ IN RADIATION RESISTOR DATA, FUNCTION 2              FIN 1540
                  C                                                          FIN 1550
ISN 0080         20 IFUN=2
ISN 0081            IF(I3) 23,21,21
ISN 0082         21 IRAD=IRAD+1
ISN 0083            IF(IRAD.GT.250) GO TO 515
ISN 0085            KR(IRAD)=I3                                              FIN 1570
ISN 0086            IF(I2V(I3).NE.0) GO TO 22
ISN 0088            WRITE(6,9111) I3,IFUN
ISN 0089            SIGNAL=.FALSE.
ISN 0090         22 EKR(IRAD)=FD
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ISN 0091            IRVAR(I3)=I3
ISN 0092            CALL READ (I,FD)                                    FIN 1590
ISN 0093            GO TO 28
ISN 0094         23 INIT=-I3
ISN 0095            CALL READ(I,FD)
ISN 0096            LAST=I3
ISN 0097            DO 25 J=INIT,LAST
ISN 0098            IRAD=IRAD+1
ISN 0099            IF(IRAD.GT.250) GO TO 515
ISN 0101            IRVAR(J)=J
ISN 0102            KR(IRAD)=J
ISN 0103            IF(I2V(J).NE.0) GO TO 25
ISN 0105            WRITE(6,9111) J,IFUN
ISN 0106            SIGNAL=.FALSE.
ISN 0107         25 EKR(IRAD)=FD
ISN 0108            WRITE(6,2002) INIT,LAST,LAST
ISN 0109         28 IF(I1) 1,20,2
ISN 0110         29 IF(I1-3) 30,30,39
                 C                                                      FIN 1620
                 C READ IN LATENT HEAT DATA, FUNCTION 3                 FIN 1630
                 C                                                      FIN 1640
ISN 0111         30 IFUN=3
ISN 0112            IPHK=IPHK+1
ISN 0113            IF(IPHK.GT.50) GO TO 515
ISN 0115            IPH(IPHK)=I3                                        FIN 1660
ISN 0116            PHT1(IPHK)=FD                                       FIN 1670
ISN 0117            PHH1(IPHK)=FD2
ISN 0118            IF(T(I3).NE.0.) GO TO 31
ISN 0120            WRITE(6,9110) I3,IFUN
ISN 0121            SIGNAL=.FALSE.
ISN 0122         31 CALL READ2 (I,PHT2(IPHK),PHH2(IPHK))
ISN 0123            IF(I1) 33,35,33
ISN 0124         33 WRITE (6,9003)
ISN 0125            GO TO 999                                           FIN 1770
ISN 0126         35 CALL READ2 (I,FD,FD2)
ISN 0127            IF(I1) 1,30,2
ISN 0128         39 IF(I1-4) 40,40,49
                 C                                                      FIN 1810
                 C READ IN CONVECTION RESISTOR DATA, FUNCTION 4         FIN 1820
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                C                                                                FIN 1830
ISN 0129        40 IFUN=4
ISN 0130           ICONK=ICONK+1
ISN 0131           IF(ICONK.GT.100) GO TO 515
ISN 0133           ICON(ICONK)=I3                                                FIN 1850
ISN 0134           IF(I2V(I3).NE.0) GO TO 41
ISN 0136           WRITE(6,9111) I3,IFUN
ISN 0137           SIGNAL=.FALSE.
ISN 0138        41 EXCON(ICONK)=FD
ISN 0139           ACON(ICONK)=FD2
ISN 0140           IRVAR(I3)=I3
ISN 0141           CALL READ2 (I,FD,FD2)
ISN 0142           IF(I1) 1,40,2
ISN 0143        49 IF(I1-5) 50,50,59
                C                                                                FIN 1960
                C READ IN ARBITRARY HEAT INPUT DATA, FUNCTION 5                  FIN 1970
                C                                                                FIN 1980
ISN 0144        50 IFUN=5
ISN 0145           QQ=FD
ISN 0146        51 CALL READ(I,FD)
ISN 0147           IF(I1.LT.0) GO TO 1
ISN 0149           IF(I3) 52,53,52
ISN 0150        52 IRB1=IRB1+1
ISN 0151           IF(IRB1.GT.100) GO TO 515
ISN 0153           NODEQ(IRB1)=I3                                                FIN 2040
ISN 0154           POWFAC(IRB1)=FD                                               FIN 2050
ISN 0155           IF(I(I3).NE.0.) GO TO 51
ISN 0157           WRITE(6,9110) I3,IFUN
ISN 0158           SIGNAL=.FALSE.
ISN 0159           GO TO 51
ISN 0160        53 IDELK=I1
ISN 0161           GO TO 51
ISN 0162        59 IF(I1-6) 60,60,69
                C                                                                FIN 2110
                C READ IN AERO HEATING DATA, FUNCTION 6                          FIN 2120
                C                                                                FIN 2130
ISN 0163        60 IFUN=6
ISN 0164           IAER1=I2
ISN 0165           IAER2=I3                                                      FIN 2150
```

```
ISN 0166        61 IAERK=IAERK+1
ISN 0167           IF(IAERK.GT.50) GO TO 515
ISN 0169           CALL READ(I,FD)                                          FIN 2170
ISN 0170           AER(IAERK)=FD                                            FIN 2180
ISN 0171           IAER(IAERK)=I3                                           FIN 2190
ISN 0172           IF(T(I3).NE.0.) GO TO 62
ISN 0174           WRITE(6,9111) I3,IFUN
ISN 0175           SIGNAL=.FALSE.
ISN 0176        62 IF(I1) 1,63,2
ISN 0177        63 IF(IAER2) 61,65,61
ISN 0178        65 CALL READ(I(1),I(2),I2AER(IAERK),ALLOC(IAERK))
ISN 0179           IF(I1) 67,61,67
ISN 0180        67 WRITE (6,9006)
ISN 0181           GO TO 999                                                FIN 2270
ISN 0182        69 IF(I1-7) 70,70,79
                C                                                           FIN 2320
                C READ IN TABULAR FUNCTION DATA, FUNCTION 7                 FIN 2330
                C                                                           FIN 2340
ISN 0183        70 IFUN=7
ISN 0184           CALL READ (I,FD)
ISN 0185           IF(I1) 1,1,71
ISN 0186        71 IKF=IKF+1
ISN 0187           IF(IKF.GT.250) GO TO 515
ISN 0189           IAF2(IKF)=I1                                             FIN 2380
ISN 0190           IAF3(IKF)=I2                                             FIN 2390
ISN 0191           IAF4(IKF)=I3                                             FIN 2400
ISN 0192           FIAF5(IKF)=FD                                            FIN 2410
ISN 0193           GO TO 70
ISN 0194        79 IF(I1-8) 80,80,89
                C                                                           FIN 2440
                C READ IN PRINT SPECIFICATION, FUNCTION 8                   FIN 2450
                C                                                           FIN 2460
ISN 0195        80 IFUN=8
ISN 0196           IF(I3) 83,81,81
ISN 0197        81 IPK=IPK+1
ISN 0198           IF(IPK.GT.700) GO TO 515
ISN 0200           IPR1(IPK)=I2
ISN 0201           IPR2(IPK)=I3                                             FIN 2490
ISN 0202           PRUNT2(IPK)=HOL(I2)                                      FIN 2500
```

```
ISN 0203          82 CALL READ(I,FD)
ISN 0204             IF(I1) 1,80,2
ISN 0205          83 INIT=-I3
ISN 0206             CALL READ(I,FD)
ISN 0207             LAST=I3
ISN 0208             WRITE (6,2002) INIT,LAST,LAST
ISN 0209             DO 84 J=INIT,LAST
ISN 0210             IPK=IPK+1
ISN 0211             IF(IPK.GT.700) GO TO 515
ISN 0213             IPR1(IPK)=I2
ISN 0214             IPR2(IPK)=J
ISN 0215             PRUNT2(IPK)=HOL(I2)
ISN 0216          84 CONTINUE
ISN 0217             GO TO 82
ISN 0218          89 IF(I1-9) 90,90,99
                  C                                                        FIN 2540
                  C READ IN PROBLEM CONSTANTS, FUNCTION 9                  FIN 2550
                  C                                                        FIN 2560
ISN 0219          90 IF(FD.EQ.0.) CALL READ2 (I,FD,FD2)
ISN 0221             M=I3
ISN 0222             IF(M.EQ. 1) GO TO 93
ISN 0224          91 IF(M.EQ. 2) GO TO 95
ISN 0226             CO(M)=FD                                              FIN 2600
ISN 0227             CALL READ2(I,FD,FD2)
ISN 0228          92 IF(I1) 97,90,2
ISN 0229          93 CO(1)=1.
ISN 0230          94 CO(ISTEP+16)=FD
ISN 0231             ISTEP=ISTEP+1                                         FIN 2690
ISN 0232             PRTIME(ISTEP)=FD2                                     FIN 2700
ISN 0233             IF(FD2.EQ.0.) PRTIME(ISTEP)=CO(4)+1.
ISN 0235             IF(PRTIME(ISTEP).GT.PRMAX) PRMAX=PRTIME(ISTEP)        FIN 2710
ISN 0237             CALL READ2 (I,FD,FD2)
ISN 0238             M=I3                                                  FIN 2660
ISN 0239             IF(M-1) 91,94,91
ISN 0240          95 CO(2)=1.
ISN 0241          96 CO(NSTEP+11)=FD
ISN 0242             NSTEP=NSTEP+1                                         FIN 2790
ISN 0243             TYM(NSTEP)=FD2                                        FIN 2800
ISN 0244             IF(FD2.EQ.0.) TYM(NSTEP)=CO(4)+1.
```

```
ISN 0246            IF(TYM(NSTEP).GT.TIMMAX) TIMMAX=TYM(NSTEP)                    FIN 2810
ISN 0248            CALL READ2 (I,FD,FD2)
ISN 0249            M=I3                                                          FIN 2760
ISN 0250            IF(I1.LT.0) GO TO 97
ISN 0252            IF(M-2) 92,96,92
ISN 0253         97 IF(PRMAX.LT.CO(4)) PRTIME(ISTEP)=CO(4)+1.
ISN 0255            IF(TIMMAX.LT.CO(4)) TYM(NSTEP)=CO(4)+1.
ISN 0257            GO TO 1
ISN 0258         99 IF(I1-10) 100,100,109
                 C                                                              FIN 2950
                 C     READ IN TIME DELAY CATHODE FOLLOWER - FUNCTION 10        FIN 2960
                 C                                                              FIN 2970
ISN 0259        100 IFUN=10
ISN 0260            CALL READ2 (I,FD,FD2)
ISN 0261            IF(I1) 1,107,101
ISN 0262        101 IF(I3) 104,102,102
ISN 0263        102 KTHMAX=KTHMAX+1
ISN 0264            IF(KTHMAX.GT.250) GO TO 515
ISN 0266            NEW(KTHMAX)=I2                                                FIN 3010
ISN 0267            KLEAD(KTHMAX)=I3                                              FIN 3020
ISN 0268            IF(T(I3).NE.0..AND.T(I2).NE.0.) GO TO 103
ISN 0270            WRITE(6,9115) I2,I3,IFUN
ISN 0271            SIGNAL=.FALSE.
ISN 0272        103 KTABLE(I1)=I1
ISN 0273            LTABLE(KTHMAX)=I1                                             FIN 3040
ISN 0274            CFLUID(KTHMAX)=FD                                             FIN 3050
ISN 0275            FULTIM(KTHMAX)=FD2
ISN 0276            IF(CFLUID(KTHMAX).EQ. 0.) GO TO 100
ISN 0278            IF(CFLUID(KTHMAX).LT.CFMIN(I1)) CFMIN(I1)=CFLUID(KTHMAX)      FIN 3070
ISN 0280            GO TO 100
ISN 0281        104 INIT=-I3
ISN 0282            NEWNOD=I2
ISN 0283            KTABLE(I1)=I1
ISN 0284            CALL READ2(I,FD,FD2)
ISN 0285            LAST=I3
ISN 0286            JSAVE=0
ISN 0287            DO 106 J=INIT,LAST
ISN 0288            KTHMAX=KTHMAX+1
ISN 0289            IF(KTHMAX.GT.250) GO TO 515
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```
ISN 0291            KFOLOW=NEWNOD+JSAVE
ISN 0292            NEW(KTHMAX)=KFOLOW
ISN 0293            KLEAD(KTHMAX)=J
ISN 0294            IF(T(J).NE.0..AND.T(KFOLOW).NE.0.) GO TO 105
ISN 0296            WRITE(6,9115) KFOLOW,J,IFUN
ISN 0297            SIGNAL=.FALSE.
ISN 0298        105 LTABLE(KTHMAX)=I1
ISN 0299            CFLUID(KTHMAX)=FD
ISN 0300            FULTIM(KTHMAX)=FD2
ISN 0301            IF(J.GT.INIT) GO TO 106
ISN 0303            IF(CFLUID(KTHMAX).EQ.0) GO TO 106
ISN 0305            IF(CFLUID(KTHMAX).LT.CFMIN(I1)) CFMIN(I1)=CFLUID(KTHMAX)
ISN 0307        106 JSAVE=JSAVE+1
ISN 0308            WRITE(6,2001)
ISN 0309            GO TO 100
ISN 0310        107 WRITE(6,9010)
ISN 0311            GO TO 999
ISN 0312        109 IF(I1-11) 110,110,119
                C                                                        FIN 3120
                C     TEMPERATURE AVERAGING SCHEME - FUNCTION 11         FIN 3130
                C                                                        FIN 3140
ISN 0313        110 IFUN=11
ISN 0314            CALL READ (I,FD)
ISN 0315            IF(I1) 1,111,111
ISN 0316        111 JOINMX=JOINMX+1
ISN 0317            IF(JOINMX.GT.50) GO TO 515
ISN 0319            JTABLE(JOINMX)=I1                                    FIN 3190
ISN 0320            NUNODE(JOINMX)=I2                                    FIN 3200
ISN 0321            INNODE(JOINMX)=I3                                    FIN 3210
ISN 0322            IF(T(I2).NE.0..AND.T(I3).NE.0.) GO TO 110
ISN 0324            WRITE(6,9115) I2,I3,IFUN
ISN 0325            SIGNAL=.FALSE.
ISN 0326            GO TO 110
ISN 0327        119 IF(I1-12) 120,120,129
                C                                                        FIN 3230
                C   FUNCTION 12 TEMPERATURE ADVANCE THROUGH A SERIES OF NODES  FIN 3240
                C                                                        FIN 3250
ISN 0328        120 IFUN=12
ISN 0329            CALL READ(I,FD)
```

```
ISN 0330            IF(I1) 1,107,121
ISN 0331        121 IF(I3) 124,122,122
ISN 0332        122 MIX=MIX+1
ISN 0333            IF(MIX.GT.200) GO TO 515
ISN 0335            LNEW(MIX)=I2                                          FIN 3300
ISN 0336            LLEAD(MIX)=I3                                         FIN 3310
ISN 0337            IF(T(I2).NE.0..AND.T(I3).NE.0.) GO TO 123
ISN 0339            WRITE(6,9115) I2,I3,IFUN
ISN 0340            SIGNAL=.FALSE.
ISN 0341        123 LLTABL(MIX)=I1
ISN 0342            KKTABL(I1)=I1                                         FIN 3330
ISN 0343            CSOLID(MIX)=FD                                        FIN 3340
ISN 0344            GO TO 120
ISN 0345        124 INIT=-I3
ISN 0346            NEWNOD=I2
ISN 0347            KKTABL(I1)=I1
ISN 0348            CALL READ(I,FD)
ISN 0349            LAST=I3
ISN 0350            JSAVE=0
ISN 0351            DO 125 J=INIT,LAST
ISN 0352            MIX=MIX+1
ISN 0353            IF(MIX.GT.200) GO TO 515
ISN 0355            LFOLOW=NEWNOD+JSAVE
ISN 0356            LNEW(MIX)=LFOLOW
ISN 0357            LLEAD(MIX)=J
ISN 0358            LLTABL(MIX)=I1
ISN 0359            CSOLID(MIX)=FD
ISN 0360            IF(T(J).NE.0..AND.T(LFOLOW).NE.0.) GO TO 125
ISN 0362            WRITE(6,9115) LFOLOW,J,IFUN
ISN 0363            SIGNAL=.FALSE.
ISN 0364        125 JSAVE=JSAVE+1
ISN 0365            WRITE(6,2001)
ISN 0366            GO TO 120
ISN 0367        129 IF(I1-13) 130,130,139
                C                                                         FIN 3360
                C  FUNCTION 13 - TEMPERATURE FEEDBACK AND DEADBAND CONTROLLER INPUT   FIN 3370
                C                                                         FIN 3380
ISN 0368        130 DO 131 J=1,3
ISN 0369            CALL READ2 (I,FD,FD2)                                 FIN 3410
```

```
ISN 0370            NBASE(J)=I3                                          FIN 3420
ISN 0371            RHO(J)=FD                                            FIN 3430
ISN 0372        131 TBASE(J)=FD2
ISN 0373            CALL READ2 (I,FD,FD2)                                FIN 3450
ISN 0374            IF(I3) 1,1,132
ISN 0375        132 DBWAIT=FD2
ISN 0376            NDEADB=I3                                            FIN 3480
ISN 0377            DELKDB=FD                                            FIN 3490
ISN 0378            CALL READ2 (I,FD,FD2)                                FIN 3500
ISN 0379            DELTDB=FD2                                           FIN 3510
ISN 0380            TDEADB=FD                                            FIN 3520
ISN 0381            CALL READ(I,FD)                                      FIN 3530
ISN 0382            GO TO 1
ISN 0383        139 IF(I1-14) 140,140,510
                C
                C  FUNCTION 14 - STEADY STATE OPTION
                C
ISN 0384        140 F14=1.
ISN 0385            ERROR=FD                                             FIN 3570
ISN 0386        141 CALL READ(I,FD)
ISN 0387            IF(I1) 1,142,142
ISN 0388        142 NUTIME=I1
ISN 0389            ADTIME(I1)=FD                                        FIN 3610
ISN 0390            GO TO 141
ISN 0391        500 IF(IPK) 501,501,502
ISN 0392        501 WRITE (6,9011)
ISN 0393            SIGNAL=.FALSE.
ISN 0394        502 IF(CO(16)) 503,503,504
ISN 0395        503 WRITE (6,9012)
ISN 0396            SIGNAL=.FALSE.
ISN 0397        504 IF(CO(4)) 505,505,506
ISN 0398        505 WRITE (6,9013)
ISN 0399            SIGNAL=.FALSE.
ISN 0400        506 RETURN
ISN 0401        510 WRITE (6,9100) I1
ISN 0402            SIGNAL=.FALSE.                                       FIN 3650
ISN 0403            RETURN                                               FIN 3670
ISN 0404        515 WRITE (6,9150) IFUN
ISN 0405        999 CONTINUE
```

```
ISN 0406          SIGNAL = .FALSE.
ISN 0407          RETURN
ISN 0408          END
```

FIN 3740

COMPILER OPTIONS - NAME= TAP7,OPT=02,LINECNT=41,SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF

```
ISN 0002            SUBROUTINE FLOW(TOME,WCP,T2ME,TABLE,DELTAT,T,C,RI,RCMIN,IERR)
ISN 0003            REAL*8 T,C,TNEW,TEMP,Q,TR,RI
ISN 0004            INTEGER*2 NEW,KLEAD,KTABLE,LTABLE,KKTABL,LLEAD,LLTABL,LNEW
ISN 0005            COMMON/FUN10/KTHMAX,NEW(250),KLEAD(250),CFLUID(250),KTABLE(30),
                   *LTABLE(250),CFMIN(30),FULTIM(250)
ISN 0006            COMMON/FUN12/MIX,KKTABL(30),LLEAD(200),LLTABL(200),LNEW(200),
                    1CSOLID(200)
ISN 0007            COMMON/CRASH/SIGNAL
ISN 0008            DIMENSION WCP(30),TABLE(104,30),T(700),C(700),TNEW(250),WCPDT(30),
                    1TEMP(200),Q(700),TR(700),RI(700)
ISN 0009            LOGICAL SIGNAL
ISN 0010            IFUN=10
ISN 0011            KERR10=0
ISN 0012            IF(KEY10.NE.1) GO TO 5
ISN 0014            KERR10=1
                    C
                    C  CALCULATE WCP AND RESET DELTAT IF NECESSARY
                    C
ISN 0015          5 DO 10 I=1,30
ISN 0016            IF(KTABLE(I).EQ. 0) GO TO 10
ISN 0018            INDEX=KTABLE(I)                                          TAP1382
ISN 0019            MC=(INDEX-1)*104+1
ISN 0020            WCP(I)=ENTERP(T2ME,TABLE(MC,1))                          TAP1384
ISN 0021            IF(.NOT. SIGNAL) RETURN
ISN 0023            IF(WCP(I).EQ. 0.) GO TO 9
ISN 0025            IF(CFMIN(I).EQ. 0.)GO TO 9
ISN 0027            IF(CFMIN(I)/WCP(I).LT.DELTAT) DELTAT=CFMIN(I)/WCP(I)     TAP1388
ISN 0029          9 WCPDT(I)=WCP(I)*DELTAT
ISN 0030         10 CONTINUE
ISN 0031            DO 20 I=1,KTHMAX
ISN 0032            KNEW=KLEAD(I)                                            TAP1391
ISN 0033         20 TNEW(I)=T(KNEW)
ISN 0034            DO 40 I=1,KTHMAX
ISN 0035            KTHNEW=NEW(I)                                            TAP1394
ISN 0036            J=LTABLE(I)                                              TAP1395
ISN 0037            IF(T2ME.LT.FULTIM(I)) GO TO 40
ISN 0039            IF(C(KTHNEW).LT. 0.) C(KTHNEW)=CFLUID(I)
```

```
ISN 0041            IF(CFLUID(I).EQ. 0.) GO TO 30
ISN 0043            T(KTHNEW)=(T(KTHNEW)*(C(KTHNEW)-WCPDT(J))+TNEW(I)*WCPDT(J))
                   */C(KTHNEW)
ISN 0044            GO TO 40
ISN 0045         30 T(KTHNEW)=TNEW(I)
ISN 0046            IF(WCP(J).EQ. 0.) GO TO 40
ISN 0048            C(KTHNEW)=WCPDT(J)
ISN 0049            IF(C(KTHNEW)/RI(KTHNEW).GE.RCMIN) GO TO 40
ISN 0051            IF(DELTAT.GE.1.0) GO TO 40
ISN 0053            IF(KEY10.NE.1) GO TO 38
ISN 0055            WRITE(6,9000) IFUN,KTHNEW
ISN 0056         38 IERR=1
ISN 0057         40 CONTINUE
ISN 0058            KEY10=IERR
ISN 0059            IF(KERR10.NE.1) IERR=0
ISN 0061            RETURN
ISN 0062            ENTRY ESTFLO(TOME,WCP,T2ME,TABLE,DELTAT,T,C,Q,TR,RI,RCMIN,IERR)
ISN 0063            IF(TOME.NE. 0.) GO TO 52
ISN 0065            DO 51 I=1,MIX
ISN 0066            N=LNEW(I)
ISN 0067         51 TEMP(I)=T(N)
ISN 0068         52 IFUN=12
ISN 0069            KERR12=0
ISN 0070            IF(KEY12.NE.1) GO TO 55
ISN 0072            KERR12=1
ISN 0073         55 DO 60 I=1,30
ISN 0074            IF(KKTABL(I).EQ. 0) GO TO 60
ISN 0076            INDEX=KKTABL(I)
ISN 0077            MC=(INDEX-1)*104+1
ISN 0078            WCP(I)=ENTERP(T2ME,TABLE(MC,1))
ISN 0079            WCPDT(I)=WCP(I)*DELTAT
ISN 0080            IF(.NOT. SIGNAL) RETURN
ISN 0082         60 CONTINUE
ISN 0083            DO 70 I=1,MIX
ISN 0084            N=LNEW(I)
ISN 0085            J=LLTABL(I)
ISN 0086            L=LLEAD(I)
ISN 0087            IF(WCP(J).EQ. 0.) GO TO 70
ISN 0089            C(N)=CSOLID(I)+WCPDT(J)
```

```
ISN 0090            IF(C(N)/RI(N).GE.RCMIN) GO TO 65
ISN 0092            IF(DELTAT.GE.1.0) GO TO 65
ISN 0094            IF(KEY12.NE.1) GO TO 63
ISN 0096            WRITE(6,9000)IFUN,N
ISN 0097         63 IERR=1
ISN 0098         65 TEMP(I)=(TEMP(I)*CSOLID(I)+WCPDT(J)*T(L))/C(N)
ISN 0099            TEMP(I)=DELTAT/C(N)*(Q(N)+TR(N)-TEMP(I)*RI(N))+TEMP(I)
ISN 0100            T(N)=TEMP(I)
ISN 0101         70 CONTINUE
ISN 0102            KEY12=IERR
ISN 0103            IF(KERR12.NE.1) IERR=0
ISN 0105            RETURN
ISN 0106       9000 FORMAT(/5X,'THE PROBLEM IS UNSTABLE IN FUNCTION',I3/10X,'THE RC PR
                   1ODUCT FOR NODE',I4,' IS LESS THAN THE CURRENT RCMIN AND MUST BE CO
                   2RRECTED')
ISN 0107            END
```

```
COMPILER OPTIONS - NAME=  TAP7,OPT=02,LINECNT=41,SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF
ISN 0002          SUBROUTINE HEATIN(T2ME,TABLE,QBETA,T,Q,DBTOT)
ISN 0003          INTEGER*2 NODEQ
ISN 0004          COMMON/FUN5/IRB1,POWFAC(100),NODEQ(100),QO,IDELK
ISN 0005          COMMON/FUN13/NBASE(3),RHO(3),TBASE(3),DBWAIT,NDEADB,DELKDB,DELTDB,T171112
                 &TDEADB
ISN 0006          COMMON/CRASH/SIGNAL
ISN 0007          EQUIVALENCE (NBASE1,NBASE(1)),(NBASE2,NBASE(2)),(NBASE3,NBASE(3))
ISN 0008          LOGICAL SIGNAL
ISN 0009          REAL*8 T,Q,QBETA
ISN 0010          DIMENSION TABLE(104,30),QBETA(100),T(700),Q(700)
ISN 0011          MC=(IDELK-1)*104+1
ISN 0012          DELKC=ENTERP(T2ME,TABLE(MC,1))                                  TAP14170
ISN 0013          IF(.NOT. SIGNAL) RETURN
                  C                                                               TAP14190
                  C   DEAD BAND CONTROLLER                                        TAP14200
                  C                                                               TAP14210
ISN 0015          IF(NDEADB) 10,10,1
ISN 0016        1 IF(DABS(T(NDEADB)-TDEADB).LT.DELTDB) GO TO 10
ISN 0018          IF(T2ME-DBGO) 10,5,5
ISN 0019        5 DBGO=T2ME+DBWAIT
ISN 0020          IF(T(NDEADB)-TDEADB) 6,10,7
ISN 0021        6 DBTOT=DBTOT+DELKDB
ISN 0022          GO TO 10
ISN 0023        7 DBTOT=DBTOT-DELKDB
                  C
                  C  RESUME THE HEATING CALCULATIONS
                  C
ISN 0024       10 DELK=RHO(1)*(T(NBASE1)-TBASE(1))+RHO(2)*(T(NBASE2)-TBASE(2))
                 &+RHO(3)*(T(NBASE3)-TBASE(3))+DELKC+DBTOT                        TAP14310
ISN 0025          DELRHO=.0C77-DELK
ISN 0026          IF(DELRHO.LE. 0.) GO TO 910
ISN 0028          DELEXP=.10C44*DELK*T2ME/DELRHO                                  TAP14340
ISN 0029          RHOEXP=DELRHO*T2ME/8.1E-6                                       TAP14350
ISN 0030          IF(DELEXP.LT.-100.) GO TO 15
ISN 0032          EX1=EXP(DELEXP)                                                 TAP14370
ISN 0033          GO TO 17
ISN 0034       15 EX1=0.
```

```
ISN 0035        17 IF(RHOEXP.GT. 150.) GO TO 19
ISN 0037           IF(RHOEXP.GT. 0.) EX2=1./EXP(RHOEXP)                    TAP14410
ISN 0039           GO TO 25
ISN 0040        19 EX2=0.
ISN 0041        25 RCONST=QO*(.0077*EX1-DELK*EX2)/DELRHO
ISN 0042           DO 30 I=1,IRB1
ISN 0043           NODQ=NODEQ(I)                                            TAP14450
ISN 0044           Q(NODQ)=POWFAC(I)*RCONST
ISN 0045           IF(T2ME.EQ. 0.) RETURN
ISN 0047           QBETA(I)=6.22E-2/(T2ME**.2)*QO*POWFAC(I)                 TAP14480
ISN 0048           IF(Q(NODQ)*.06 .LT.QBETA(I)) Q(NODQ)=Q(NODQ)*.94+QBETA(I) TAP14490
ISN 0050        30 CONTINUE
ISN 0051           RETURN
ISN 0052       910 WRITE (6,9010) DELK
ISN 0053      9010 FORMAT(1HO,40HTHE REACTOR IS PROMPT CRITICAL, DELTA K=,1PE10.5)   T
ISN 0054           SIGNAL=.FALSE.
ISN 0055           RETURN
ISN 0056           END
```

COMPILER OPTIONS - NAME= TAP7,OPT=02,LINECNT=41,SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF

```
ISN 0002            SUBROUTINETABIN(TABLE,KDEP,KIND)                                TABI1010
                  C TABIN                                                           TABI1020
                  C                                                                 TABI1030
                  C THIS ROUTINE READS IN THE TABULAR DATA                          TABI1040
                  C                                                                 TABI1050
ISN 0003            COMMON/FUN7/IKF,IAF2(250),IAF3(250),IAF4(250),FIAF5(250)
ISN 0004            COMMON/VARY/ NODVAR,IRVAR(999)
ISN 0005            INTEGER*2 IRVAR
ISN 0006            INTEGER*2 KIND,KDEP
ISN 0007            DIMENSION TABLE(104,30),KDEP(30),KIND(30)                       TABI1060
ISN 0008            COMMON/CRASH/SIGNAL
ISN 0009            LOGICAL SIGNAL                                                  TABI1080
ISN 0010            DIMENSION ITAB(3),I(3)                                          TABI1090
ISN 0011            EQUIVALENCE (ITAB(1),NTAB),(ITAB(2),NIND),(ITAB(3),NDEP),       TABI1100
                   *(I(1),N1)
ISN 0012        101 CALL READ2 (ITAB,PER,CONST)                                     TABI1120
ISN 0013            IF(NTAB) 120,120,105
ISN 0014        105 IF(NDEP.NE.1) GO TO 109
ISN 0016            DO 108 J=1,IKF
ISN 0017            IF(NTAB-IAF4(J)) 108,106,108
ISN 0018        106 NODVAR=NODVAR+1
ISN 0019            K=IAF2(J)
ISN 0020            IRVAR(K)=IAF2(J)
ISN 0021        108 CONTINUE
ISN 0022        109 TABLE (1,NTAB)=PER                                              TABI1140
ISN 0023            KDEP(NTAB)=NDEP                                                 TABI1150
ISN 0024            TABLE(2,NTAB)=CONST                                             TABI1160
ISN 0025            KIND(NTAB)=NIND                                                 TABI1170
ISN 0026            N1=1                                                            TABI1180
ISN 0027            DO 110J=3,103,2                                                 TABI1190
ISN 0028            CALL READ2 (I,TABLE(J,NTAB),TABLE(J+1,NTAB))                    TABI1200
ISN 0029            IF(N1)101,110,110
ISN 0030        110 CONTINUE                                                        TABI1220
ISN 0031            WRITE (6,111)NTAB                                               TABI1230
ISN 0032        111 FORMAT(103HOYOU HAVE FORGOTTEN THE MINUS ONE AT THE END OF THE PRETABI1240
                   1VIOUS TABLE OR USED MORE THAN 50 POINTS ON TABLE I2)            TABI1250
ISN 0033            SIGNAL=.FALSE.                                                  TABI1260
```

```
ISN 0034
ISN 0035        120 RETURN
                END
```

TABI1280

COMPILER OPTIONS - NAME= TAP7,OPT=02,LINECNT=41,SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF

```
ISN 0002            SUBROUTINE TAVG(TOME,C,T,WCP,DELTAT,RI,RCMIN,IERR)
ISN 0003            REAL*8 CSUM,CTSUM,T,C,RI
ISN 0004            INTEGER*2 JTABLE,NUNODE,INNODE
ISN 0005            COMMON/FUN11/JOINMX,JTABLE(50),NUNODE(50),INNODE(50)
ISN 0006            DIMENSION C(700),T(700),WCP(30),RI(700)
ISN 0007            IF(TOME.EQ. 0.) GO TO 100
ISN 0009            IFUN=11
ISN 0010            CSUM=0.
ISN 0011            CTSUM=0.
ISN 0012            KERR11=0
ISN 0013            IF(KEY11.NE.1) GO TO 5
ISN 0015            KERR11=1
ISN 0016          5 DO 50 I=1,JOINMX
ISN 0017            INNOD=INNODE(I)
ISN 0018            NUNOD=NUNODE(I)
ISN 0019            JTABL=JTABLE(I)
ISN 0020            IF(I.EQ.1) GO TO 10
ISN 0022            IF(NUNODE(I).NE.NUNODE(I-1)) GO TO 20
ISN 0024         10 CSUM=CSUM+WCP(JTABL)*DELTAT
ISN 0025            CTSUM=CTSUM+WCP(JTABL)*DELTAT*T(INNOD)
ISN 0026            IF(I.EQ.JOINMX) GO TO 30
ISN 0028            GO TO 50
ISN 0029         20 NUNOD=NUNODE(I-1)
ISN 0030         30 IF(CSUM.EQ. 0.) GO TO 40
ISN 0032            C(NUNOD)=CSUM
ISN 0033            IF(C(NUNOD)/RI(NUNOD).GE.RCMIN) GO TO 35
ISN 0035            IF(DELTAT.GE.1.0) GO TO 35
ISN 0037            IF(KEY11.NE.1) GO TO 33
ISN 0039            WRITE(6,9000) IFUN,NUNOD
ISN 0040         33 IERR=1
ISN 0041         35 T(NUNOD)=CTSUM/CSUM
ISN 0042         40 CSUM=WCP(JTABL)*DELTAT
ISN 0043            CTSUM=WCP(JTABL)*DELTAT*T(INNOD)
ISN 0044         50 CONTINUE
ISN 0045            KEY11=IERR
ISN 0046            IF(KERR11.NE.1) IERR=0
ISN 0048            RETURN
```

```
ISN 0049        100 TOME=1.
ISN 0050            RETURN
ISN 0051        9000 FORMAT(/5X,'THE PROBLEM IS UNSTABLE IN FUNCTION',I3/10X,'THE RC PR
                1ODUCT FOR NODE',I4,' IS LESS THAN THE CURRENT RCMIN AND MUST BE CO
                2RRECTED')
ISN 0052            END
```

```
COMPILER OPTIONS - NAME=  TAP7,OPT=02,LINECNT=41,SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF
ISN 0002            SUBROUTINE STEADY(KEY,T,MAXNO,DELTAT)                    STEA1010
ISN 0003            COMMON/FUN14/F14,ERROR,NUTIME,ADTIME(20)                 STEA1020
ISN 0004            REAL*8 T, TSAVE                                          STEA1030
ISN 0005            DIMENSION T(700),TSAVE(700)
ISN 0006            KEY=1                                                    STEA1050
ISN 0007            DO 50 I=1,MAXNO                                          STEA1060
ISN 0008            IF(T(I).EQ.0.) GO TO 50                                  STEA1070
ISN 0010            DELTA=DABS((T(I)-TSAVE(I))/(T(I)*DELTAT))                STEA1080
ISN 0011            IF(DELTA.LE.ERROR) GO TO 50                              STEA1090
ISN 0013            KEY=0                                                    STEA1100
ISN 0014            GO TO 90                                                 STEA1110
ISN 0015         50 CONTINUE                                                 STEA1120
ISN 0016            GO TO 101                                                STEA1130
ISN 0017         90 DO 100 I=1,MAXNO                                         STEA1140
ISN 0018        100 TSAVE(I)=T(I)                                            STEA1150
ISN 0019        101 RETURN                                                   STEA1160
ISN 0020            END                                                      STEA1170
```

COMPILER OPTIONS - NAME= TAP7,OPT=02,LINECNT=41,SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF

```
ISN 0002            SUBROUTINE LAT (PHT1,PHH1,PHT2,PHH2,QDEL,T,TPREV,        LAT 1010
                   1Q,RI,TR,DELTAT,TIME,K)                                   LAT 1020
                  C LAT                                                      LAT 1030
                  C                                                          LAT 1040
                  C     ROUTINE FOR LATENT HEAT EFFECTS                      LAT 1050
                  C                                                          LAT 1060
ISN 0003            REAL*8 T,RI,TR,Q,TPREV                                   LAT 1070
ISN 0004            COMMON/CRASH/SIGNAL
ISN 0005            LOGICAL SIGNAL                                           LAT 1090
ISN 0006            IF(QDEL)2,3,2                                            LAT 1100
ISN 0007          2 IF(TPREV-PHT2)16,4,16                                     LAT 1110
ISN 0008          4 TLH=PHT2                                                 LAT 1120
ISN 0009            IF(PHH2)30,30,31                                         LAT 1130
ISN 0010         30 WRITE (6,32)TIME,K                                       LAT 1140
ISN 0011            SIGNAL=.FALSE.                                           LAT 1150
ISN 0012            RETURN                                                   LAT 1160
ISN 0013         32 FORMAT(1H0//40H PROBLEM CUT OFF BY LATENT HEAT ROUTINE.F12.2,I5)  LAT 1170
ISN 0014         31 EMDLH=PHH2                                               LAT 1180
ISN 0015          6 QCH=(TR+Q-TLH*RI)*DELTAT+QDEL                            LAT 1190
ISN 0016            IF(ABS(QCH)-EMDLH)7,8,8                                  LAT 1200
ISN 0017          8 WRITE (6,9)TIME,K,T                                      LAT 1210
ISN 0018          9 FORMAT(1H0//24H LATENT HEAT INFORMATIONF12.2,I5,F10.2)   LAT 1220
ISN 0019            QDEL=0.0                                                 LAT 1230
ISN 0020          1 TPREV=T                                                  LAT 1240
ISN 0021            RETURN                                                   LAT 1250
ISN 0022          3 IF(T-PHT2)10,29,11                                       LAT 1260
ISN 0023         10 IF(TPREV-PHT2)12,1,13                                    LAT 1270
ISN 0024         12 IF(T-PHT1)14,20,15                                       LAT 1280
ISN 0025         14 IF(TPREV-PHT1)1,1,26                                     LAT 1290
ISN 0026         26 WRITE(6,9)TIME,K,T                                       LAT 1300
ISN 0027         16 TLH=PHT1                                                 LAT 1310
ISN 0028            EMDLH=PHH1                                               LAT 1320
ISN 0029            GO TO 6                                                  LAT 1330
ISN 0030         15 IF(TPREV-PHT1)26,26,1                                    LAT 1340
ISN 0031         13 WRITE (6,9)TIME,K,T                                      LAT 1350
ISN 0032            GO TO 4                                                  LAT 1360
ISN 0033         11 IF(TPREV-PHT2)13,13,1                                    LAT 1370
```

```
ISN 0034          7 IF(QCH)17,19,18                                    LAT 1380
ISN 0035         17 IF(QDEL)19,19,8                                    LAT 1390
ISN 0036         19 QDEL=QCH                                           LAT 1400
ISN 0037            T=TLH                                              LAT 1410
ISN 0038            GO TO 1                                            LAT 1420
ISN 0039         18 IF(QDEL)8,19,19                                    LAT 1430
ISN 0040         29 IF(TPREV-PHT2)8,1,8                                LAT 1440
ISN 0041         20 IF(TPREV-PHT1)8,1,8                                LAT 1450
ISN 0042            END                                                LAT 1460
```

COMPILER OPTIONS - NAME= TAP7,OPT=02,LINECNT=41,SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF

```
ISN 0002            FUNCTION ENTERP(ARG,TAB)                                    ENTE1010
                C ENTERP                                                        ENTE1020
                C                                                               ENTE1030
                C     LINEAR INTERPOLATION ROUTINE                              ENTE1040
                C                                                               ENTE1050
ISN 0003            COMMON/CRASH/SIGNAL
ISN 0004            COMMON/TABND/INDEX                                          ENTE1070
ISN 0005            LOGICAL SIGNAL                                              ENTE1080
ISN 0006            DIMENSION TAB(104)                                          ENTE1090
ISN 0007            IF(TAB(2)) 1,2,1
ISN 0008          1 ENTERP=TAB(2)                                               ENTE1110
ISN 0009            RETURN                                                      ENTE1120
ISN 0010          2 ARGI = ARG
ISN 0011          4 DO 15 I=2,100,2
ISN 0012            IF (TAB(I+1) - ARGI) 12,10,6
ISN 0013          6 IF(I-2) 20,20,8
ISN 0014          8 ENTERP= (ARGI-TAB(I-1))/(TAB(I+1)-TAB(I-1))*(TAB(I+2)-TAB(I))  ENTE1170
                  1+TAB(I)                                                      ENTE1180
ISN 0015            RETURN                                                      ENTE1190
ISN 0016         10 ENTERP = TAB(I+2)
ISN 0017            RETURN                                                      ENTE1210
ISN 0018         12 IF(I-2) 15,15,14
ISN 0019         14 IF (TAB(I+1)-TAB(I-1)) 16,15,15
ISN 0020         15 CONTINUE
ISN 0021         16 IF(TAB(1)) 20,20,18
ISN 0022         18 ARGI=ARGI-TAB(1)
ISN 0023            IF (ARGI -TAB(I-1)) 4,4,18
ISN 0024         20 WRITE(6,1000) INDEX,ARG
ISN 0025       1000 FORMAT(20X,40('*')/5X'THE ARGUMENT EXCEEDS THE EXTENT OF TABLE',I3
                  1/5X'THE ARGUMENT IS',E12.4)
ISN 0026            SIGNAL=.FALSE.                                              ENTE1280
ISN 0027            RETURN                                                      ENTE1290
ISN 0028            END                                                         ENTE1330
```

COMPILER OPTIONS - NAME= TAP7,OPT=02,LINECNT=41,SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF

```
ISN 0002          BLOCK DATA                                          ENTE1340
ISN 0003          COMMON/CRASH/ SIGNAL
ISN 0004          LOGICAL SIGNAL                                      ENTE1360
ISN 0005          END                                                 ENTE1370
```

COMPILER OPTIONS - NAME= TAP7,OPT=02,LINECNT=41,SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF

```
ISN 0002            SUBROUTINE READ (I,X)
                    C                                                        READ1030
                    C SUBROUTINE TO READ IN BASIC DATA WITH ONE E15.5 FIELD   READ1040
                    C                                                        READ1050
ISN 0003            COMMON/FLAG/ KFLAG
ISN 0004            DATA CCHECK/'C'/
ISN 0005            DIMENSION I(3)                                           READ1060
ISN 0006            READ (5,1002) C,I,X
ISN 0007            IF(CCHECK.EQ.C) GO TO 5
ISN 0009          4 WRITE(6,2001) I,X
ISN 0010            RETURN
ISN 0011          5 KFLAG=0
ISN 0012            WRITE(6,2002) I,X
ISN 0013            RETURN
ISN 0014       1002 FORMAT(A1,I4,2I5,E15.5,50H
                   1         )
ISN 0015       2001 FORMAT(1X,3I5,E15.5,50H
                   1        )
ISN 0016       2002 FORMAT(1X,'*',I4,2I5,E15.5,50H
                   1           )
ISN 0017            ENTRY READ2(I,X,Y)
                    C                                                        READ1020
                    C READ ROUTINE TO READ IN DATA WITH TWO E15.5 FIELDS      READ1030
                    C                                                        READ1040
ISN 0018            READ (5,1003)I,X,Y                                       READ1060
ISN 0019            WRITE (6,2003) I,X,Y
ISN 0020            RETURN                                                   READ1080
ISN 0021       1003 FORMAT(3I5,2E15.5,35H                              )     READ1090
ISN 0022       2003 FORMAT(1X,3I5,2E15.5,35H                             )
ISN 0023            END                                                      READ1100
```

COMPILER OPTIONS - NAME= TAP7,OPT=02,LINECNT=41,SOURCE,EBCDIC,NCLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF

```
ISN 0002            FUNCTION QECK (TIME,FLAG,T,TABH,TABM,TABA,TABB,TABREX,TABS      QECK1010
                   1,IBFLAG                                                        QECK1020
                   2,I2AER,ALLOC                                                   QECK1030
                   3,TABTLT,TABMLM,TABT,A,B,E,GAM,TABPR,EK)                        QECK1040
                C QECK                                                             QECK1050
                C                                                                  QECK1060
                C     ECKERT EQUATION FOR AERODYNAMIC HEATING                      QECK1070
                C                                                                  QECK1080
ISN 0003            DIMENSION TABH(104),TABM(104),TABA(104),TABB(104),TABREX(104),  QECK1090
                   1TABS(104),TABTLT(104),TABMLM(104),TABT(104),TABPR(104)         QECK1100
ISN 0004            COMMON/CRASH/SIGNAL
ISN 0005            LOGICAL SIGNAL                                                 QECK1120
ISN 0006            IF(FLAG)19,2,19                                                QECK1130
ISN 0007          2 H=ENTERP(TIME,TABH)                                            QECK1140
ISN 0008            IF(.NOT.SIGNAL) GO TO 7                                        QECK1150
ISN 0010            EM=ENTERP(TIME,TABM)                                           QECK1160
ISN 0011            IF(.NOT.SIGNAL) GO TO 7                                        QECK1170
ISN 0013            IF(IBFLAG)4,3,4                                                QECK1180
ISN 0014          4 BETA=1.0                                                       QECK1190
ISN 0015            GO TO 5                                                        QECK1200
ISN 0016          3 ALPH=ENTERP(TIME,TABA)                                         QECK1210
ISN 0017            IF(.NOT.SIGNAL) GO TO 7                                        QECK1220
ISN 0019          5 REXM=10.0**(ENTERP(H,TABREX))                                  QECK1230
ISN 0020            IF(.NOT.SIGNAL) GO TO 7                                        QECK1240
ISN 0022          6 S=ENTERP(EM,TABS)                                              QECK1250
ISN 0023            IF(.NOT.SIGNAL) GO TO 7                                        QECK1260
ISN 0025          9 TLOTI=ENTERP(EM,TABTLT)                                        QECK1270
ISN 0026            IF(.NOT.SIGNAL) GO TO 7                                        QECK1280
ISN 0028            EMLOMI=ENTERP(EM,TABMLM)                                       QECK1290
ISN 0029            IF(.NOT.SIGNAL) GO TO 7                                        QECK1300
ISN 0031         11 TINF=ENTERP(H,TABT)                                            QECK1310
ISN 0032            IF(.NOT.SIGNAL) GO TO 7                                        QECK1320
ISN 0034            EN=.71**E*(GAM-1.0)/2.0*(EMLOMI*EM)**2                         QECK1330
ISN 0035            TL=TLOTI*TINF                                                  QECK1340
ISN 0036            TR=TL*(1.0+EN)                                                 QECK1350
ISN 0037            FLAG=1.0                                                       QECK1360
ISN 0038         19 IF(IBFLAG)1,20,1                                               QECK1370
```

```
ISN 0039        20  ALPHL=ALLOC-ALPH                                    QECK1380
ISN 0040            IF(I2AER)12,14,12                                    QECK1390
ISN 0041        12  ALPHL=-ALPHL                                        QECK1400
ISN 0042        14  IF(TABB(4))15,16,15                                 QECK1410
ISN 0043        15  BETA=ENTERP(ALPHL,TABB)                             QECK1420
ISN 0044            IF(.NOT.SIGNAL) GO TO 7                              QECK1430
ISN 0046            GO TO1                                               QECK1440
ISN 0047        16  IF(ALPHL)17,18,18                                    QECK1450
ISN 0048        17  BETA=TABB(3)*ALPHL+1.0                              QECK1460
ISN 0049            GO TO1                                               QECK1470
ISN 0050        18  BETA=TABB(5)*ALPHL+1.0                              QECK1480
ISN 0051         1  TLPOTL =.5 *(1.0+(T+459.69)/TL)+.22*EN               QECK1490
ISN 0052            PR3K=10.0**(ENTERP(TLPOTL*TL,TABPR))                 QECK1500
ISN 0053            IF(.NOT.SIGNAL) GO TO 7                              QECK1510
ISN 0055            QECK=BETA*EK*(S*REXM*EM/TLPOTL**1.69)**A*EM          QECK1520
                   1**B*PR3K*(TR-T-459.69)                               QECK1530
ISN 0056     7       RETURN                                              QECK1540
ISN 0057            END                                                  QECK1550
```

COMPILER OPTIONS - NAME= TAP7,OPT=02,LINECNT=41,SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF

```
ISN 0002            FUNCTION QRW(TIME,FLAG,IBFLAG,T,TABH,TABM,TABA,A,B,E,GAM,EK,TABREXQRW 1010
                   1 ,I2AER,ALLOC                                                  QRW 1020
                   2,TABT,TABB)                                                    QRW 1030
                C QRW                                                              QRW 1040
                C                                                                  QRW 1050
                C     R-W EQUATION FOR AERODYNAMIC HEATING                         QRW 1060
                C                                                                  QRW 1070
ISN 0003            DIMENSION TABH(104),TABM(104),TABA(104),TABB(104),TABREX(104), QRW 1080
                   1TABT(104)                                                      QRW 1090
ISN 0004            COMMON/CRASH/SIGNAL
ISN 0005            LOGICAL SIGNAL                                                 QRW 1110
ISN 0006            IF(FLAG)19,2,19                                                QRW 1120
ISN 0007          2 H=ENTERP(TIME,TABH)                                            QRW 1130
ISN 0008            IF(.NOT.SIGNAL) GO TO 7                                        QRW 1140
ISN 0010            EM=ENTERP(TIME,TABM)                                           QRW 1150
ISN 0011            IF(.NOT.SIGNAL) GO TO 7                                        QRW 1160
ISN 0013            IF(IBFLAG)4,3,4                                                QRW 1170
ISN 0014          4 BETA=1.0                                                       QRW 1180
ISN 0015            GO TO 5                                                        QRW 1190
ISN 0016          3 ALPH=ENTERP(TIME,TABA)                                         QRW 1200
ISN 0017            IF(.NOT.SIGNAL) GO TO 7                                        QRW 1210
ISN 0019          5 REXM=10.0**(ENTERP(H,TABREX))                                  QRW 1220
ISN 0020            IF(.NOT.SIGNAL) GO TO 7                                        QRW 1230
ISN 0022            TINF=ENTERP(H,TABT)                                            QRW 1240
ISN 0023            IF(.NOT.SIGNAL) GO TO 7                                        QRW 1250
ISN 0025            EN=.71**E*(GAM-1.0)/2.0*EM**2                                  QRW 1260
ISN 0026            TR=TINF*(1.0+EN)                                               QRW 1270
ISN 0027            FLAG=1.0                                                       QRW 1280
ISN 0028         19 IF(IBFLAG)1,20,1                                               QRW 1290
ISN 0029         20 ALPHL=ALLOC-ALPH                                               QRW 1300
ISN 0030            IF(I2AER)12,14,12                                              QRW 1310
ISN 0031         12 ALPHL=-ALPHL                                                   QRW 1320
ISN 0032         14 IF(TABB(4))15,16,15                                            QRW 1330
ISN 0033         15 BETA=ENTERP(ALPHL,TABB)                                        QRW 1340
ISN 0034            IF(.NOT.SIGNAL) GO TO 7                                        QRW 1350
ISN 0036            GO TO1                                                         QRW 1360
ISN 0037         16 IF(ALPHL)17,18,18                                              QRW 1370
```

```
ISN 0038          17 BETA=TA3B(3)*ALPHL+1.0                                    QRW 1380
ISN 0039             GO TO1                                                    QRW 1390
ISN 0040          18 BETA=TA3B(5)*ALPHL+1.0                                    QRW 1400
ISN 0041     1       IF((EM.EQ.0.).AND.(A.EQ.0.).AND. (B.EQ.0.)) GO TO 77      QRW 1410
ISN 0043             QRW=BETA*EK*(REXM*EM)**A*EM**B*(TR-T-459.69)/(TR-TINF)    QRW 1420
ISN 0044             GO TO 7                                                   QRW 1430
ISN 0045    77       QRW=0.                                                    QRW 1440
ISN 0046     7        RETURN                                                   QRW 1450
ISN 0047              END                                                      QRW 1460
```